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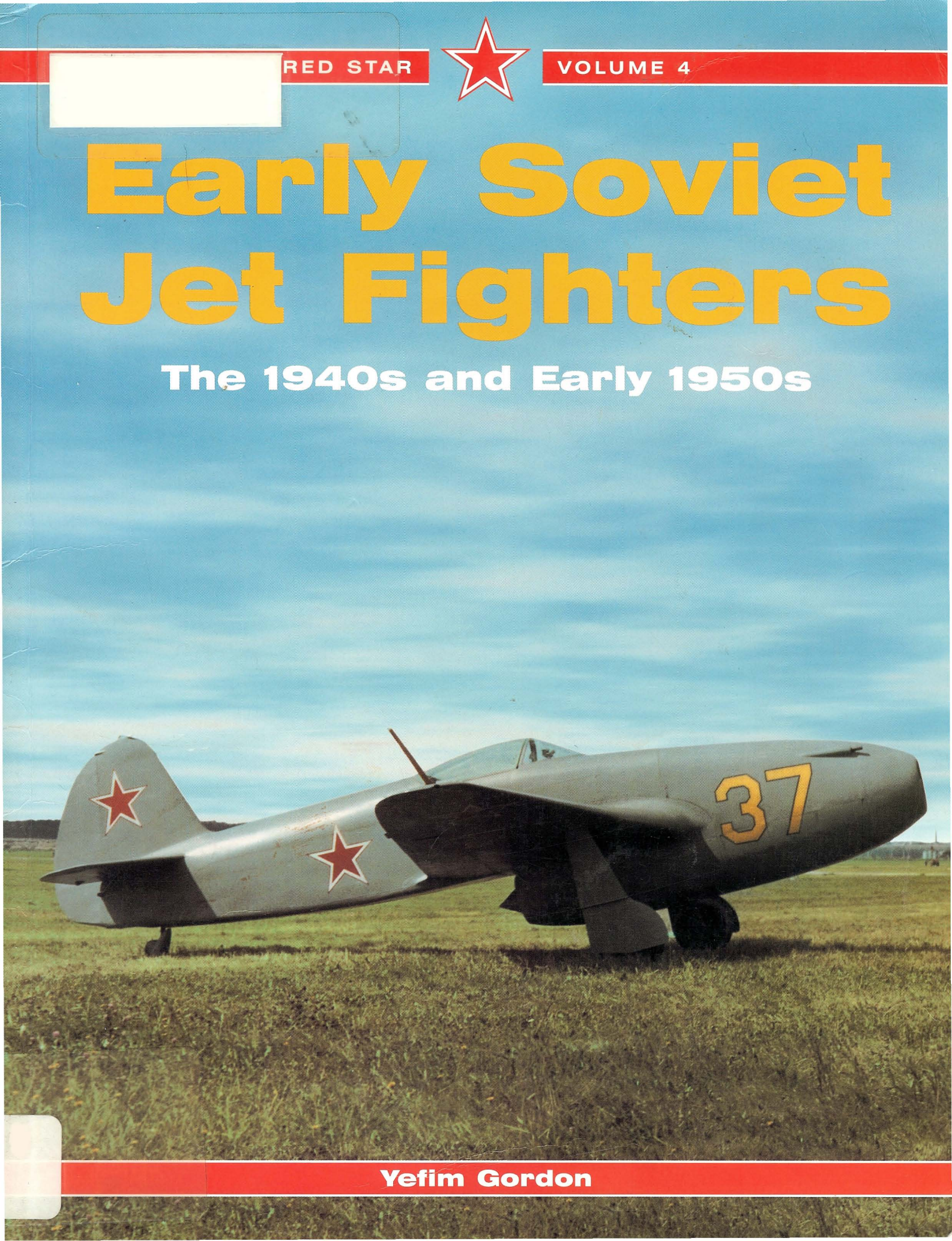
Early Soviet Jet Fighters

The 1940s and Early 1950s



Yefim Gordon

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Original translation by Dmitriy and Sergey Komissarov

Midland Publishing

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Title page: The Yak-25 of 1947 was the last straight-wing jet aircraft developed by the Yakovlev design bureau. It never entered production, being outperformed by the swept wing MiG-15.

Below: The I-302 (FP) represented one of the many attempts to improve the Mikoyan OKB's first jet, the MiG-9. The offset position of the 37-mm cannon was an attempt to cure the engines' tendency to flame out when the cannons were fired.

Introduction

By the end of the Second World War the USA and Great Britain had developed practical jet fighters, even if they came a bit too late to take part in the action. Germany achieved even greater success, using jet fighters operationally in the closing stages of the war. The Soviet Union had fallen behind in this area, which is due to the Soviet government's scant attention to jet aircraft development and the lack of indigenous jet engines. True, as early as 1939 the design bureau led by Nikolay N. Polikarpov (OKB-51) had begun working on mixed-power fighters; the lead was quickly followed by other design bureaux headed by Aleksandr S. Yakovlev (OKB-115), Semyon A. Lavochkin (OKB-301), Artyom I. Mikoyan (OKB-155), Pavel O. Sukhoi (OKB-134) and Semyon M. Alekseyev (OKB-21). (OKB = ***op****ytno-kon****strook****torskoye byu****ro*** – experimental design bureau; the number is a code allocated for security reasons.) These fighters employed ramjets or liquid-fuel rocket motors to give them a performance boost as required, but for various reasons none of them achieved production and service.

Several rocket-powered fighters were brought out as well, including the BI developed by A. Ya. Bereznyak and A. M. Isayev, the '302' designed by A. G. Kostikov and the Mikoyan I-270 (aka *izdeliye* Zh). (*Iz****del****iye* (product) such and such was a common way of coding Soviet military hardware). However, the dangers associated with the rocket motor running on corrosive and/or toxic fuels and oxidisers, coupled with the motor's limited operation time, meant this was not a viable powerplant for a high-speed aircraft.

Early research and development work on turbojet engines in the USSR dates back to the late 1930s. In 1938 Arkhip M. Lyul'ka and a group of engineers who shared his ideas came up with the project of the RTD-1 turbojet rated at 400 kgp (881 lb st). Approving the project, the People's Commissariat of Aircraft Industry (NKAP – *Na****rod****nyy komissari****aht*** *aviatsionnoy pro****mysh****lennosti*) allocated funds for manufacturing a prototype engine; meanwhile, Luyl'ka was transferred to Leningrad to continue his work on jet engines at SKB-1 (Special Design Bureau – *spetsi****ahl'****noye kon****strook****torskoye byu****ro***). The RTD-1 evolved into the RD-1 (*reak****tiv****nyy* ***dvig****atel'* – jet engine) delivering 500 kgp (1,102 lb st) and featuring a multi-stage axial compressor. By August 1941 the RD-1 prototype was 75% complete and SKB-1 was working on an even more powerful engine, the 600-kgp (1,322-lb st) M-18; unfortunately, the outbreak of the war caused all work to be put on hold.

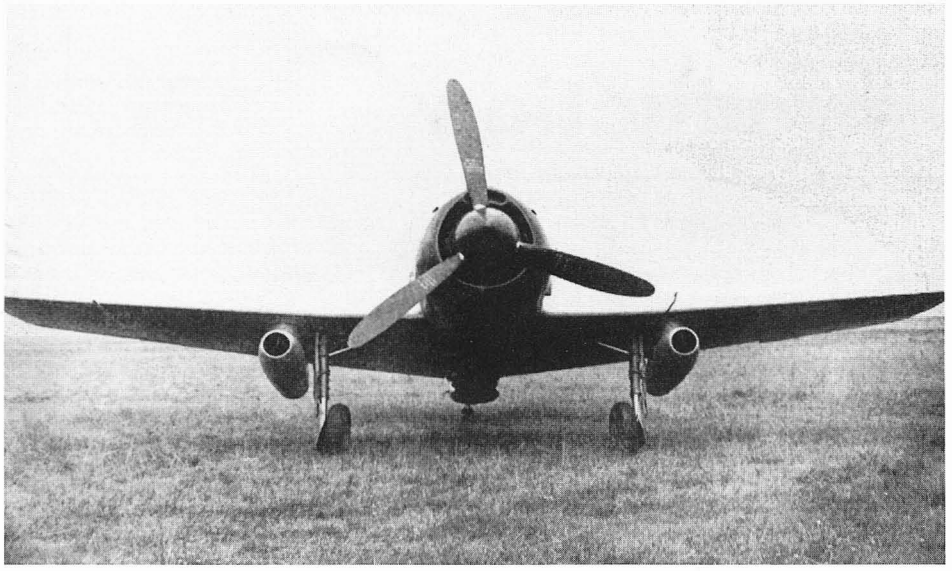
Above: The Lavochkin La-7R equipped with a liquid-fuel rocket booster in the aft fuselage was one of the precursors of the jet era.

The La-9R was another tested and failed approach to the problem, featuring underwing ramjet boosters.

In early 1942 the Council of People's Commissars, one of the Soviet Union's highest government bodies, considered several jet fighter projects, including Mikhail I. Goodkov's proposal to re-engine the LaGG-3 fighter with an RD-1 turbojet. Concurrently the jet engine development programme was dusted off in accordance with Iosif V. Stalin's personal orders. In reality, however, the work really got underway in 1944 when Lyul'ka was put in charge of the gas turbine engine R&D section at a newly-established institute specialising in propulsion research.

Jet aircraft and jet engine development became a priority task for the Soviet aircraft industry after the war. Huge resources were committed to this task; still, all the money in the world can't buy you time, and the research and development effort was certainly going to be a lengthy one, which meant the service entry of the first Soviet jets would occur rather later than desired. Therefore, to speed up the work the Soviet government chose to make use of Germany's experience in this field.

In 1945 the Soviet Union came into possession of many materials pertaining to jet aircraft development. The rich war booty included complete aircraft and jet engines. Many of these aircraft underwent rigorous testing at the Red Banner State Research Institute of the Soviet Air Force (GK NII VVS – *Gosoo****dar****stvennyy krasnozna****myon****nyy na-*



Above and below: two views of the Lavochkin '126' fighter after the addition of ramjet boosters.

ooch**-no-is**sled**ovatel'skiy insti**toot** Vo**yen**no-voz**doosh**nykh sil*) and the Flight Research Institute (LII – ***Lyot**no-is**sled**ovatel'skiy insti-**toot); they were also carefully studied at the Central Aero- & Hydrodynamics Institute named after Nikolay Ye. Zhukovskiy (TsAGI – *Tsen**trahl**'nyy **a**ero- i **ghid**rodina**mich**eskiy insti**toot***). The detailed reports filed after these tests and examinations were circulated to various organizations within the NKAP framework, including design bureaux. The same procedure applied to the captured engines. The Junkers Jumo 004B and BMW 003A turbojets rated at 900 kgp (1,984 lb st) and 800 kgp (1,763 lb st) respectively were of special interest to the Soviet engineers because they had reached production status; therefore, it was decided to urgently launch production of these engines in the USSR.

The '120R', another 'rocket rider' derivative of the La-7, seen during manufacturer's flight tests.

On 28th April 1945 the People's Commissar of Aircraft Industry issued an order to the effect that Chief Designer Vladimir Yakovlevich Klimov, whose engine design bureau had been evacuated from Rybinsk (Yaroslavl' Region) to Ufa during the war, should prepare a set of detail drawings of the Jumo 004B, whereupon the reverse-engineered turbojet was to enter production at the Ufa aero-engine factory No. 26 as the RD-10. Klimov's closest aide Nikolay D. Kuznetsov was put in charge of the actual copying job. Another NKAP order issued on 13th June 1945 tasked Chief Designer of the Kazan' aero-engine factory No. 16 Kolosov with similarly copying the BMW 003A and launching production of this engine as the RD-20. The decision to build the RD-10 and RD-20 was confirmed by the State Defence Committee's directive of 20th July 1945 titled 'On studying and mastering production of German jet aircraft designs'. Production of both models got underway in 1946.

Still, despite the high priority attached in the immediate post-war months to copying and producing the German engines, it was clear that progress in the field of Soviet engine design could only be attained by relying on own resources and indigenous models.

Back in the autumn of 1944 Lyul'ka's design team had begun testing the S-18 turbojet, a further development of the pre-war RD-1; the S stood for ***sten**dovyy*, meaning that the Soviet Union's first operational jet engine was intended for bench trials and was not yet flight-cleared. At this stage the designers had their first acquaintance with engine surge at high rpm; the surge was bad enough to wreck the engine completely. Still, changes introduced into the design cured the problem and the S-18 successfully completed its trials. The latter included comparative tests with the Jumo 004B, showing that the Soviet engine had not only higher thrust (1,250 kgp/2,755 lb st) but a lower dry weight and specific fuel consumption. These encouraging results led to the decision to develop a flight-cleared version designated TR-1 (***toor**boreak**tiv**nyy [**dvi-**gatel']* – turbojet engine) and manufacture a small trials batch. To this end a new design bureau, OKB-165, was established, with Arkhip M. Lyul'ka as Chief Designer.

On 2nd April 1946 I. V. Stalin, Chairman of the Council of People's Commissars, held a briefing on the prospects of Soviet aviation, including jet aircraft development. One of the items on the agenda was the possibility of copying the Messerschmitt Me 262A-1a fighter, an example of which had been evaluated by GK NII VVS in August-November 1945, and putting it into production at one of the Soviet aircraft factories. In its day the Me 262 had an

impressive top speed of 850 km/h (459 kts), heavy armament comprising four 30-mm (1.18 calibre) cannons and was generally well designed. However, the idea was rejected for various reasons.

By then several Soviet design bureaux had a number of high-speed aircraft projects in the making; many of them fell for the 'German' layout with two turbojet engines under or on the wings *à la* Me 262 (which, incidentally, was also employed by the British Gloster Meteor). For instance, Pavel O. Sukhoi's OKB used it for the *izdeliye* K fighter, the Mikoyan OKB developed a Me 262 look-alike designated I-260, while the Lavochkin OKB came up with the '160' fighter (the first fighter to have this designation) and the Alekseyev OKB with the I-21 designed along similar lines. A notable exception was the Yakovlev OKB because A. S. Yakovlev cordially disliked heavy fighters, preferring lightweight single-engined machines. (Later Yakovlev *did* resort to the twin-engined layout, but that was in the early 1950s when the Yakovlev OKB brought out the Yak-120 (Yak-25) twinjet interceptor which lies outside the scope of this book.)

As an insurance policy in case one OKB failed to achieve the desired results, the Soviet government usually issued a general operational requirement (GOR) for a new aircraft to several design bureaux at once in a single Council of People's Commissars (or Council of Ministers) directive. This was followed by an NKAP (or MAP, *Mini**ster**stvo aviatsi**on**noy pro**mysh**lennosti* – Ministry of Aircraft Industry) order to the same effect. This was also the case with the new jet fighters. Initially all the abovementioned OKBs designed their fighters around Soviet copies of the Jumo 004B or BMW 003A engines; later the more promising indigenous TR-1 came into the picture.

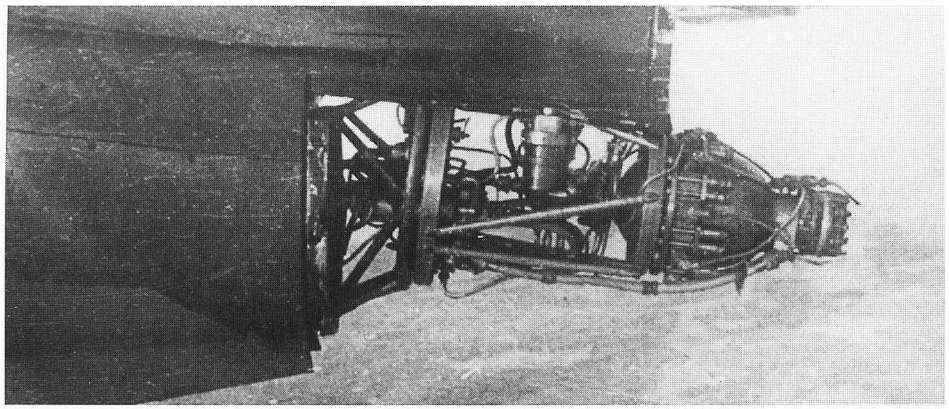
It should be noted that in the early post-war years the Soviet defence industry enterprises continued to operate pretty much in wartime conditions, working like scalded cats. In particular, the Powers That Be imposed extremely tight development and production schedules on the design bureaux and production factories tasked with developing and manufacturing new military hardware. The schedules were closely monitored not only by the ministry to which the respective OKB or factory belonged but also by the notorious KGB. 'Missing the train' could mean swift and severe reprisal not only for the OKB head and actual project leaders but also for high-ranking statesmen who had responsibility for the programme. Nevertheless, even though the commencement of large-scale R&D on jet aircraft had been ordered as far back as May 1944, no breakthrough had been achieved by early 1946. For instance, the aircraft industry failed to comply with the orders to build pre-production batches of jet fighters

Above: This Yak-7B was converted in to a research aircraft with two Merkoolov DM-4S ramjet boosters.

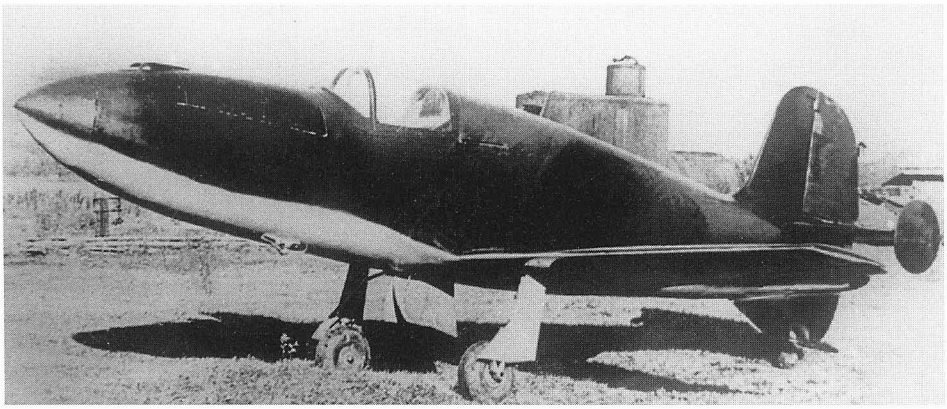
Above: The Yak-3RD experimental mixed-power fighter. The rocket motor installation in the tail is not obvious in this view, as the nozzle is closed by a pointed fairing.

Above: The Sukhoi Su-5 fighter featured a 'pseudo-turbojet engine' in the tail with an engine-driven compressor. It never got past the prototype stage.

Another mixed-power aircraft from Sukhoi, the Su-7R with a liquid-fuel rocket motor in the tail.

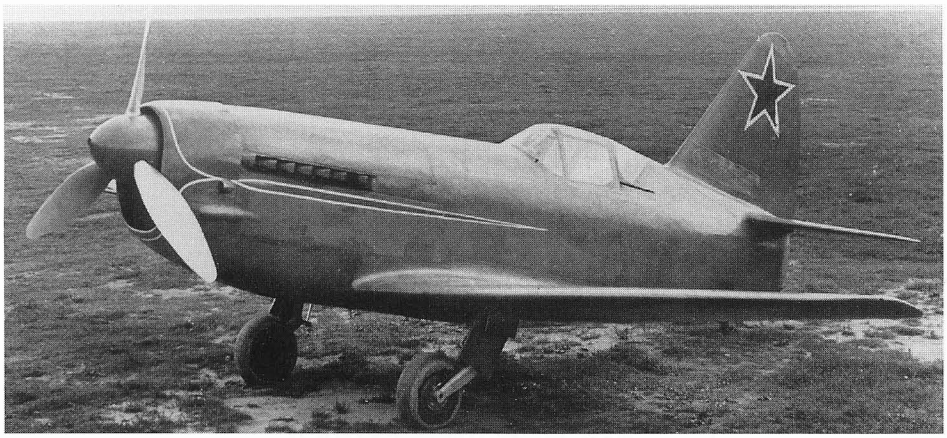


Above: Close-up of the Yak-3R's Glooshko RD-1-KhZ rocket motor with the cowling removed.



Above: The BI rocket-powered interceptor designed by Bereznyak and Isayev.

Above: The '4302' rocket-powered interceptor makes an interesting comparison with the BI. Like the latter type, it remained an experimental aircraft.



The Mikoyan I-250 mixed-power fighter employed the same powerplant as the Su-5.

in time for the traditional August flypast held at Moscow's Tushino airfield; only two jets, the MiG-9 and Yak-15, participated in the flypast on that occasion. This was all the more aggravating because jet fighters had been in production in Great Britain since 1944 and in the USA since early 1945. Unfortunately the Soviet aero-engine factories encountered major difficulties when mastering production of jet engines; hence in early 1946 jet engines were produced in extremely limited numbers, suffering from low reliability and having a time between overhauls (TBO) of only 25 hours.

As was customary in the Soviet Union in those days, someone had to pay for this, and scapegoats were quickly found. In February-March 1946 People's Commissar of Aircraft Industry A. I. Shakhoorin, Soviet Air Force C-in-C Air Marshal A. A. Novikov, the Air Force's Chief Engineer A. K. Repin and Main Acquisitions Department chief N. P. Seleznyov and many others were removed from office, arrested and mostly executed.

The early post-war years presaged the Cold War era, and the Soviet leaders attached considerable importance not only to promoting the nation's scientific, technological and military achievements but also to flexing the Soviet Union's military muscles for the world to see. This explains why the government was so eager to see new types displayed at Tushino, regardless of the fact that some of the aircraft had not yet completed their trials – or, worse, did not meet the Air Force's requirements. Thus, the grand show at Tushino on 3rd August 1947 featured a whole formation of jet fighter prototypes: the Yak-19, the Yak-15U, the Yak-23, three Lavochkin designs – the '150', the '156' and the '160', plus the MiG-9, the Su-9 and the Su-11.

Sometimes the initial production aircraft selected for the flypast lacked armament or important equipment items. This was not considered important; the world had to see the new aircraft at all costs. Behold the achievements of socialism! Feel the power of the Soviet war machine! Fear ye! Still, despite this air of ostentation, the achievements and the power were there beyond all doubt; the Soviet Union's progress in aircraft and aero engine technologies was indeed impressive, especially considering the ravages of the four-year war. It just happened that, because of urgent need, some things which could not be developed in-country quickly enough had to be copied; and copied they were – and with reasonably high quality at that.

Thus by the end of the 1940s the Soviet Union had not only caught up with the West as far as jet aviation was concerned but gained a lead in certain areas. The first Soviet jet fighters dealt with in this book were instrumental in reaching this goal.

Chapter 1

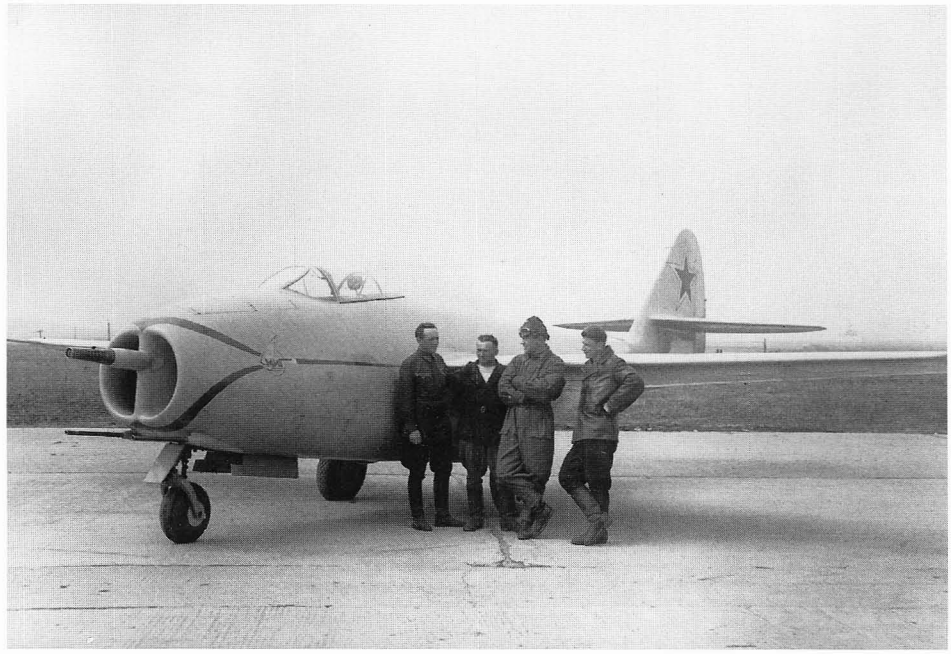
The first Mikoyan jet

As already noted in the introduction, at the end of the Great Patriotic War the State Defence Committee geared scientific organisations and experimental design bureaux to the solution of tasks associated with the post-war technical progress in the field of military aviation; a number of OKBs were tasked with developing jet-powered aircraft.

In 1944-45 the I-250 mixed-power fighter (manufacturer's designation *izdeliye* N) was built and tested by OKB-155 under the direction of Artyom Ivanovich Mikoyan and his closest associate Mikhail Iosifovich Gurevich. It featured a VRDK 'pseudo-turbojet engine' in the tail, the axial compressor being driven via an extension shaft by a Klimov VK-107R 12-cylinder liquid-cooled piston engine which also drove a variable-pitch propeller. This was followed by the I-270 (*izdeliye* Zh) interceptor powered by a twin-chamber liquid-fuel rocket motor. The former fighter was built in limited numbers, while the I-270 was purely a research aircraft; however, by the end of the war it became clear that the bet should be placed on turbojet engines.

In February 1945 the Council of People's Commissars issued a directive requiring several design bureaux to develop, build and submit for testing single-seat jet fighters. In particular, the OKB of Plant No. 155 was tasked with developing a single-seat fighter with two 'BMW 003 type jet engines' (*sic*) and a weapons complement comprising one 57-mm (2.24 calibre) or 37-mm (1.45 calibre) cannon and two 23-mm (.90 calibre) cannons. The fact that the specification called for so potent armament was due to the fighter's intended main role of combatting heavy bombers.

Another directive in which specifications for the aircraft were laid down more precisely followed on 9th April. According to this document the twin-engined fighter designed by OKB-155 was to have a maximum speed of 900 km/h (486.48 kts) at sea level and 910 km/h (491.89 kts) at 5,000 m (16,404 ft), climbing to this altitude within four minutes; maximum range was specified as 820 km (509 miles). The fighter was to be armed with one 57-mm (or 37-mm) cannon and a pair of 23-mm cannons. Three prototypes were to be completed, the first of which was to enter flight test by 15th March 1946.

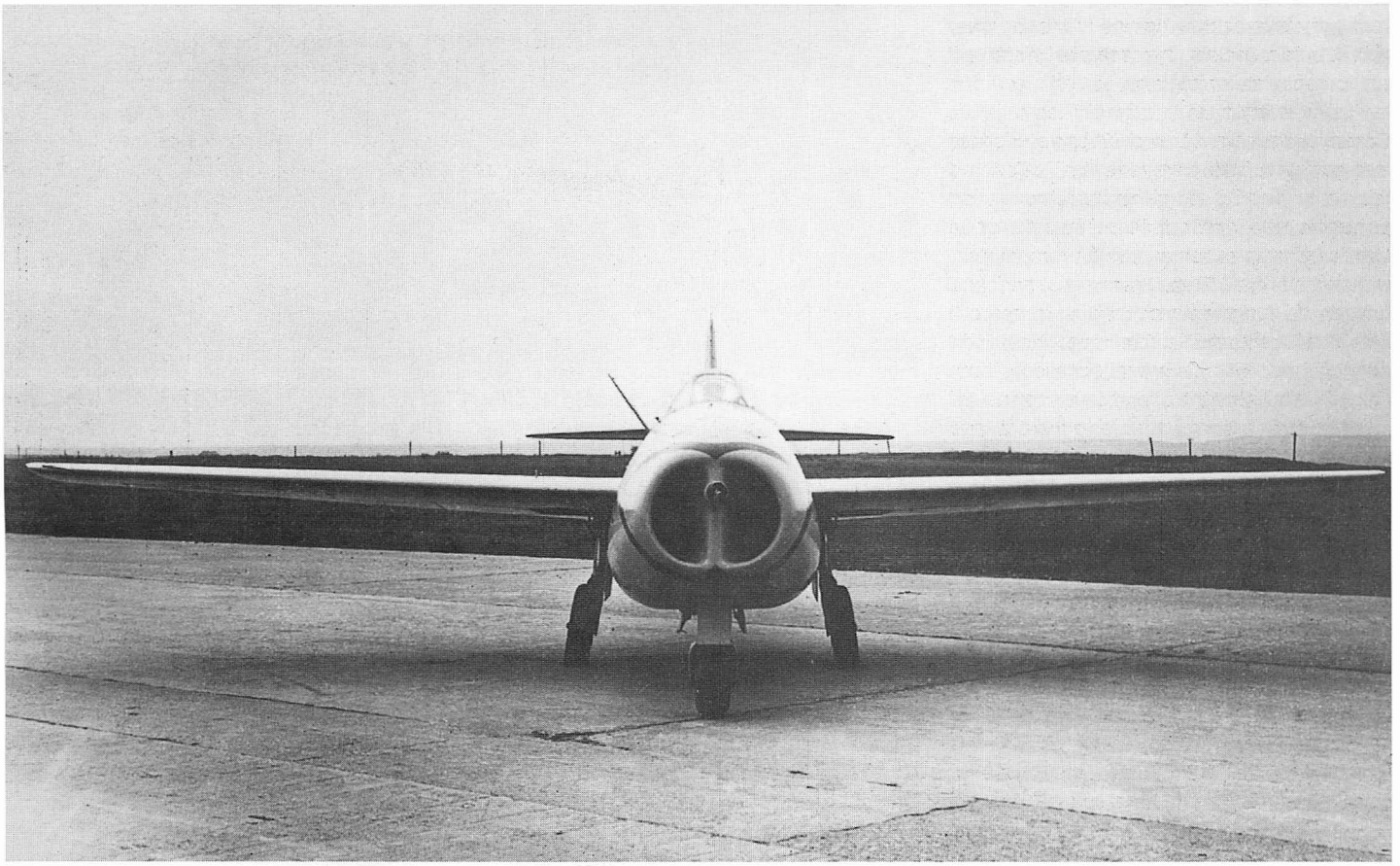


OKB-155 test pilot Aleksey N. Grinchik (second from right) with members of the Mikoyan OKB's flight test facility staff beside the ill-fated first prototype I-300 (F-1). Note the Mikoyan OKB logo on the nose.

It should be noted that throughout the year of 1945 the Soviet government was extremely concerned over the very slow tempo of jet aircraft development and service introduction. Hardly a month passed without a new directive being issued by the State Defence Committee and the Government; ever more stringent time limits were set and tasks were redefined, but to no avail – try as they would, the Mikoyan OKB engineers could not get the work to go faster. The State Defence Committee's directive of 20th July 1945 titled 'On studying and mastering production of German jet aircraft designs' demanded that the aircraft industry (and, notably, aircraft design bureaux) unfailingly fulfil the tasks assigned to them. Once again, more precisely formulated tasks were given to the 'fighter makers' concerning the development of jet fighters intended to use two types of German engines that were being put in series production. (As noted in the introductory section, by mid-1945 Government decisions had been taken and appropriate directives issued by NKAP requiring series production of the Junkers Jumo 004B and BMW 003 jet engines to be launched at Soviet aero-engine factories.)

The idea of copying (or 'reproducing in basic layout') the Me 262 was considered not only in the top echelon but also in virtually every 'fighter' OKB. The German fighter's layout with the engines in underwing nacelles was not ignored by OKB-155 either. Responding to the specific operational requirement issued by the government, in May 1945 the designers started work on the I-260 twin-engined fighter project which bore an extraordinary resemblance to the Me 262. The aircraft featured a battery of heavy cannons installed in the fuselage nose and was powered by turbojet engines mounted under the wings. The project was completed by the end of the year. However, the designers did not deem this layout to be the optimum one. Wishing to reduce drag and achieve the fullest possible use of the engines' thrust, they decided to place the powerplant in the forward fuselage, with the engines exhausting under the rear fuselage. In June 1945, barely a month after the commencement of work on the I-260, the OKB-155 initiated work on the alternative project of the I-300 fighter which also bore the in-house designation '*izdeliye* F'. It was envisaged that the first prototype would be completed by mid-October.

Above: Final assembly of the first I-300 (F-1) at the Mikoyan OKB's experimental shop (MMZ No. 155). Note the solid mainwheel discs. The nose of another I-300 is visible on the right.



This head-on view of the F-1 shows to advantage the narrow track of the undercarriage.

Above: Aleksey Grinchik climbs into the cockpit of the F-1. The original solid mainwheels have been replaced with spoked ones. Note that the MiG logo is carried on the port side only.

A side view of the first prototype. The I-300 was a rather corpulent fighter.

Soviet aircraft designers were already well familiar with the so-called 'pod-and-boom' layout thanks to the numerous captured German documents that had been thoroughly studied by TsAGI and other scientific institutions of the People's Commissariat of Aircraft Industry. This layout offered some advantages (improved airfield performance and handling and better view from the cockpit), but it also had certain shortcomings (the designers would have to tackle a number of difficult questions associated with accommodating the armament and the nosewheel leg, protecting the aft fuselage from the jet exhaust, choosing the optimum arrangement of the horizontal tail etc.).

Detail design of the *izdeliye* F fighter was approved in the late autumn of 1945, whereupon construction of a full-scale mock-up was begun. Concurrently MMZ No. 155 (*Mos**kov**skiy ma**shin**ostroi**te**l'nyy za**vod*** – Moscow Machinery Factory No. 155, the experimental production facility of the Mikoyan OKB) started manufacturing components and assemblies for the three prototypes (they were allocated the designations F-1, F-2 and F-3 respectively). A. G. Broonov was leading project engineer, while A. T. Karev was appointed engineer in charge of the manufacturer's flight tests.

The I-300 (*izdeliye* F) was an all-metal single-seat twin-engined aircraft featuring unswept mid-set wings and a nose air intake. The wings had slotted flaps and Frise ailerons. The underside of the aft fuselage was protected from the hot engine efflux by a heat shield featuring a sandwich of heat-resistant steel sheets with a corrugated core between them. The cantilever tailplanes were placed outside the flow of hot gases. The cockpit was not pressurised. The pilot was protected by two 12-mm (.047-in.) armour plates and a 60-mm (2.36-in.) bulletproof windscreen, as well as by the instrument panel and an ammunition box.

The fuel system comprised four fuselage tanks and six wing tanks with a total capacity of 1,625 litres (357.5 Imp gal). T-2 (tractor grade) kerosene was used as fuel, since special jet fuel was not yet produced at the time. Each BMW 003 engine was provided with an individual Riedel two-stroke two-cylinder starter running on aviation gasoline.

The armament comprised one 57-mm N-57 (*izdeliye* 120P) cannon built into the air intake splitter and two 23-mm NS-23 (*izdeliye* 115P) cannon accommodated in the lower forward fuselage at the base of the air intake. The centrally mounted N-57 cannon weighed 135 kg (298 lb) and had a rate of fire of 230 rounds per minute, the muzzle velocity being 600 m/sec (1,920 ft/sec). The I-300 was the first Soviet fighter to employ a tricycle undercarriage which had earlier been tested on the MiG-8 'Ootka' experimental tail-first aircraft. (Note: The name of the MiG-8 contains a pun. ***Oot**ka* means 'duck' in Russian, but the word is also used to denote the canard or tail-first layout.) The main landing gear units retracted outwards into the wings and the nose unit aft, the nosewheel being housed in the air intake splitter.

When the mock-up had been officially approved in January 1946 the People's Commissariat of Aircraft Industry issued order No. 157ss calling for the construction and testing of a prototype; however, as a matter of fact, the first prototype of the I-300 (F-1) had already been completed and submitted for manufacturer's flight tests in the closing days of the preceding year, on 30th December. Between January and March 1946 the F-1 underwent ground testing, engine adjustment and development work. Commencement of static tests was delayed because in the meantime TsAGI had evolved new recommendations concerning the structural strength of high-speed aircraft (this was a very timely measure, as evidenced by subsequent events); as a result, the aft fuselage and empennage of the first prototype had to be reinforced.

Meanwhile, the Council of People's Commissars of the USSR issued a new directive (No. 472-191ss) dated 26th February, followed by an NKAP order to the same effect on 27th March. These laid down more precise requirements for the performance of the *izdeliye* F fighter. Thus, compared to the State Defence Committee directive of 9th April 1945, the requirements relating to armament, speed, rate of climb and service ceiling remained unchanged. The required range at 5,000 m (16,4000 ft) and 0.45 of the maximum design speed (V_{max}) was to reach 600 km (373 miles), the endurance being 1.5 hours; at 10,000 m (32,808 ft) and V_{max} the range was to reach 800 km (497 miles), endurance at this altitude and speed being 50 minutes.

All necessary modifications to the first prototype I-300 (F-1) were completed on 6th March, when eight months had elapsed since the commencement of design work. On 23rd March the fighter was trucked to the airfield of the Flight Research Institute (LII) in Ramenskoye. (Note: The town of Ramenskoye was nearest to LII's airfield at the time. Gradually, however, a new town grew right next to the airfield, presently becoming the town of Zhukovskiy, and now the airfield should be regarded as 'the one in Zhukovskiy', though Ramenskoye is still used occasionally.) The prototype's avionics and equipment followed the standard of that time; the F-1 had an RSI-6 radio, an RPKO-10M direction finder (***rah**diopolu**kom**pas*), a 12-A-10 DC battery and a KP-14 breathing apparatus (*kislo**rod**nyy pree**bor*** – oxygen apparatus) with a 4-litre (0.88 Imp gal) oxygen bottle. To provide power for electrical systems and radio equipment, the prototype aircraft were fitted with powerful German LK-2000 generators produced by Bosch (later, Soviet-designed GSK-1500 generators were fitted instead). Concurrently, static tests of a specially built airframe commenced in the spring of 1946. To determine the actual strength the load was increased until the structure failed.

In the course of ground testing and development work the first unpleasant surprises associated with the pod-and-boom layout emerged. The jet efflux of the engines produced a marked fall in pressure under the aft fuselage which caused the aircraft to tilt tail-down during the first engine runs on the ground. In flight this could lead to a tendency to pitch up depending on the engine thrust. Besides, the problem of protecting the aft fuselage from the jet exhaust was not so easy to solve, as it turned out. The steel heat shield and the duralumin fuselage skin had different thermal expansion ratios, which resulted in deformation of the aft fuselage underside. A decision was taken to urgently rework the aft fuselage; an articulated heat shield featuring an ingenious cooling system was quickly developed and fitted to the prototype, replacing the original shield which was installed rigidly. Now the aircraft no longer tilted tail-down during engine runs; however, the new shield created new problems even as it eliminated old ones: it vibrated during engine operation. Once again the designers had to seek a solution.

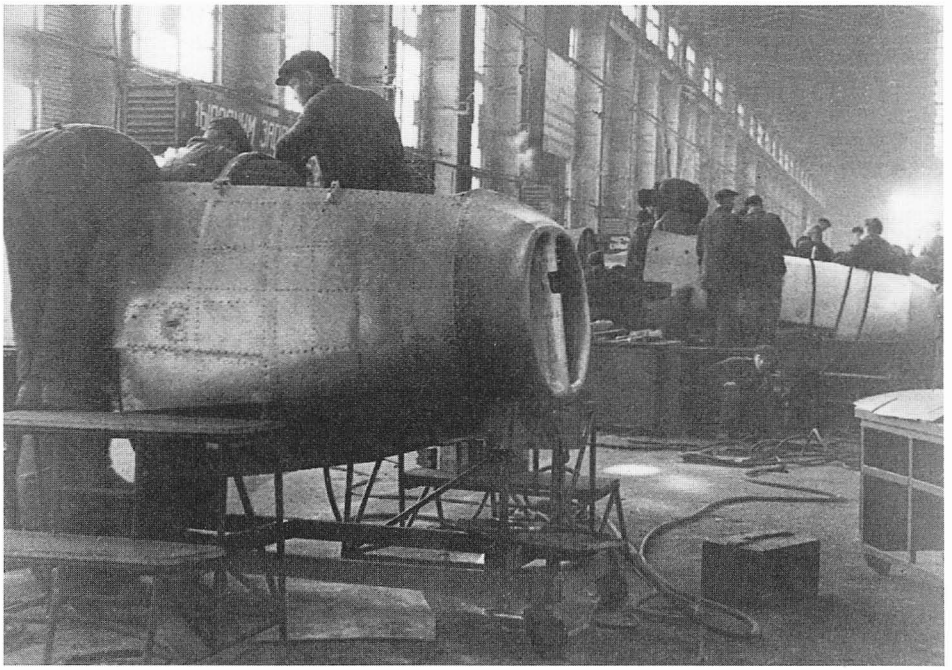
On 9th April 1946 the Council of Ministers issued directive No. 796-318ss, which stated, among other things, that the Council of Ministers had accepted the proposal made by Chief Designer A. I. Mikoyan and his deputy M. I. Gurevich to begin flight tests of a single-seat fighter powered by two 800-kgp (1,763-lb st) RD-20 turbojets. Pursuant to an order issued by the Ministry of Aircraft Industry Aleksey N. Grinchik, a test pilot and engineer of the Flight Research Institute, was entrusted with the manufacturer's flight tests of the first jet aircraft designed by OKB-155. It was not by chance that the choice fell on an LII pilot rather than a Mikoyan OKB pilot. Firstly, considering the magnitude of the task to be solved and the novel character of the technology, a decision was taken to commit LII to the testing of the first Soviet jet fighters from the start. Secondly, the institute's specialists already had accumulated some experience with jets, having evaluated and studied in detail a number of captured German aircraft.

Preparations for testing the first prototype (aircraft F-1) were completed by mid-April. Prior to the initial flight tests the centrally-mounted 57-mm 100P (N-57) cannon was removed and replaced by a metal dummy,

and 30 kg (66 lb) of ballast were placed in the ammunition box. To obtain the necessary centre of gravity (CG) position the first two fuselage tanks and the service tank were filled with fuel to capacity, while the wing tanks were filled with 134 kg (295 lb) of fuel. Engine runs and taxying on the hangar apron were conducted on 12th April, and the first high-speed taxi run took place three days later. On 19th April Grinchik made a hop in the F-1 to the height of 4 m (13 ft).

Finally, on 24th April 1946 the I-300 made its first real flight. This day became an important milestone in the history of Soviet aviation; for the first time an indigenous turbojet-powered aircraft had become airborne. Grinchik made two circuits of the airfield area and made a safe landing. The flight, after which the pilot reported no problems, lasted only six minutes. Until then, Mikoyan OKB employees had had to put up with caustic questions like 'Will this hole fly?' (a reference to the large air intake in the nose giving the I-300 a very unconventional appearance by the standards of the day). Now the sceptics were put to shame; Grinchik had demonstrated that *this hole* could indeed fly, and fly well at that!

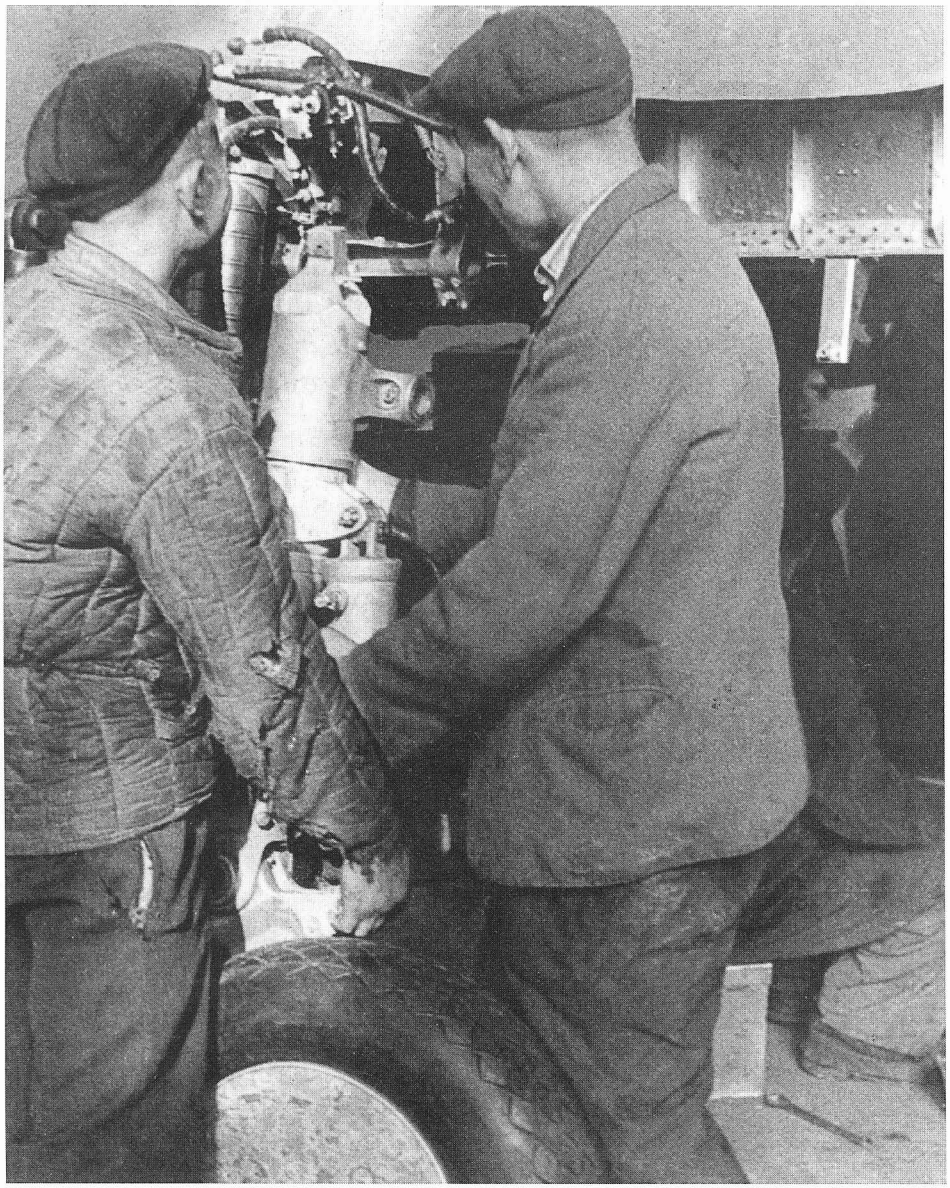
A few hours later Mikhail I. Ivanov, a test pilot of Yakovlev's OKB-115, performed the maiden flight of one more Soviet jet fighter – the Yak-Jumo (better known as the Yak-15; see Chapter Two). Thus, 24th April 1946 became a double grand occasion for Soviet airmen; it doesn't often happen that two new aircraft types make their first flights in the same country on a single day.



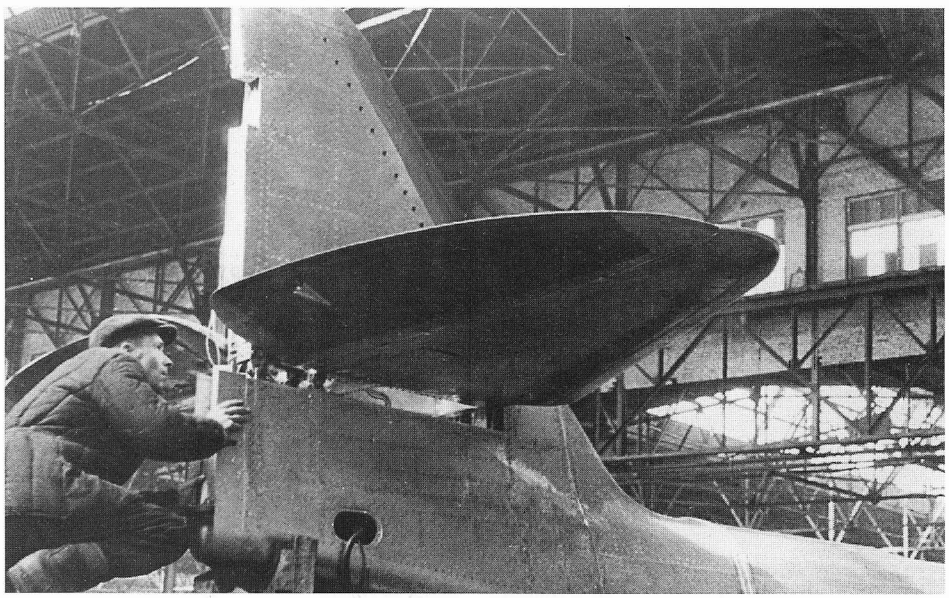
The fuselages of MiG-9s of the initial production batch being assembled at the Kiubyshev aircraft factory No.1. These fighters were virtually hand-crafted.

On 6th May the Ministry of Aircraft Industry issued order No. 277s 'On the manufacturer's flight tests of the I-300 single-seat fighter designed by A. I. Mikoyan', in keeping with which the testing was initiated at the LII airfield. The F-1's the second flight was performed on 7th May, the third flight taking place on 11th May. In the course of the eighth flight violent vibration manifested itself in the area of the engines; it could not be eliminated during the next three flights. Nevertheless, the I-300's superiority over the best piston-engined fighters was obvious right from the

The MiG-9 final assembly shop at aircraft factory No. 1. Note the B-25 in the background, probably an NKAP executive transport.



Above: Installation of the port main landing gear unit; note the wing root rib.



Assembly of the MiG-9's tail unit.

start. In the course of the tests the F-1 attained a top speed of 920 km/h (497.29 kts); the service ceiling was 13,000 m (42,651 ft), and 4.5 minutes were needed to climb to 5,000 m (16,404 ft). However, new problems surfaced, one of them being longitudinal instability (a tendency to 'see-sawing'); the the prototype's flights were plagued by persistent vibration of the ventral heat shield.

On 5th June Chief Designer Artyom I. Mikoyan held an expanded session of the OKB's technical council; among its participants were TsAGI specialists headed by Academician Mstislav V. Keldysh, and test pilot Aleksey N. Grinchik. Having looked through the test materials and listened to the pilot's comments, Keldysh said that the vibrations were a consequence of the pod-and-boom layout and that the engines ought to be transferred to the wings. He also suggested that the second prototype, which was nearing completion at the time, be urgently sent to TsAGI for investigation. In turn, A. T. Karev, the fighter's project engineer, declared that the vibration was due to insufficient rigidity of the heat shield which should be stiffened. Following his usual practice, Mikoyan took a wise decision, accepting all the proposals: he decided to send the second prototype to TsAGI for wind tunnel tests and increase the rigidity of the shield at the same time. Thus, the designers endeavoured to gradually eliminate the defects, determining the fighter's performance characteristics and assessing its handling qualities in the process.

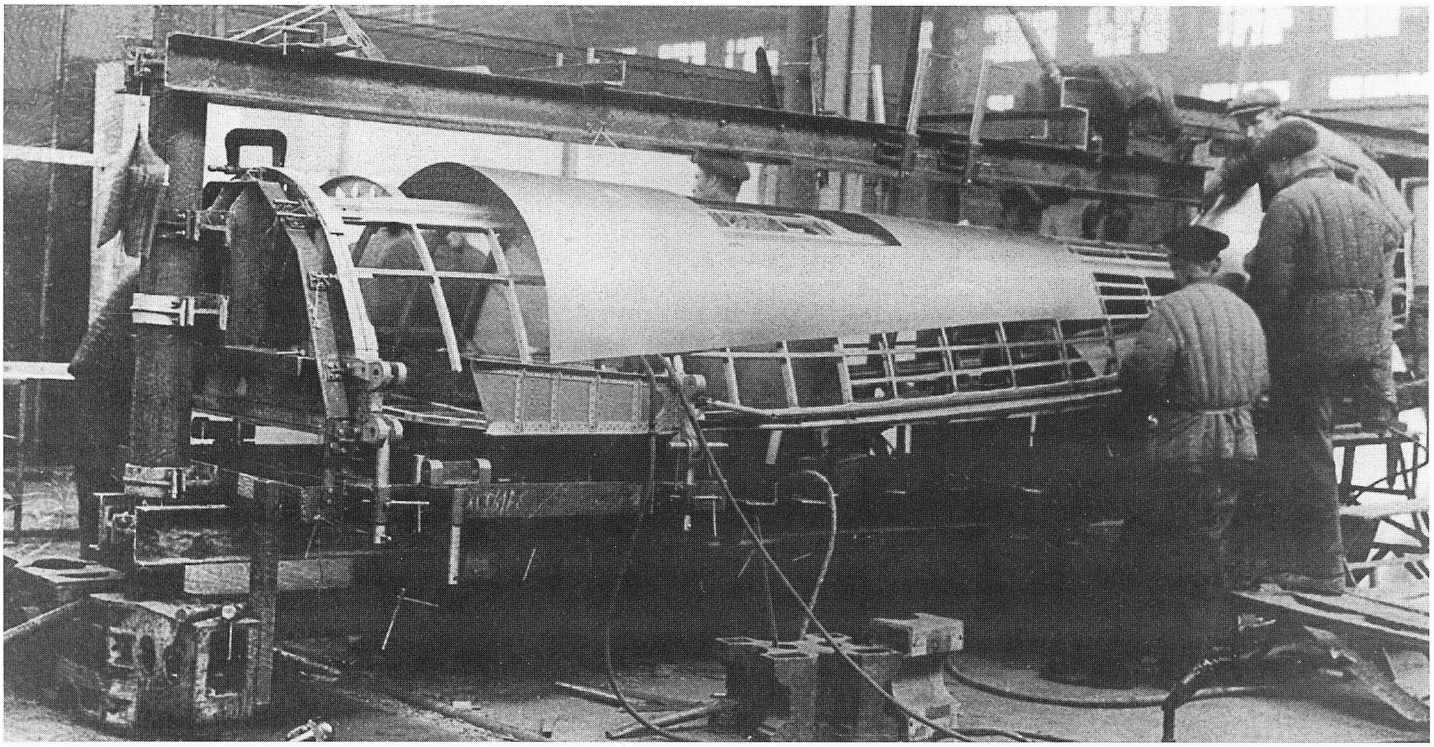
On 2nd July the Ministry of Aircraft Industry issued order No. 420ss which stated the following:

'As a follow-up to directive No. 296-318ss of 9th April 1946, the Council of Ministers through its directive No. 1249-511ss of 15th June of this year accepted the offer by Chief Designer A. I. Mikoyan and Vice Chief Designer Gurevich to develop a single-seat fighter powered by two 1,000-kgp [2,204-lb st] *RD-21 turbojets or by two BMW 003S turbojets and included it into the plan for prototype construction; it also took notice of a statement by Mikoyan and Gurevich to the effect that they had submitted for flight testing a single-seat fighter powered by two 800-kgp* [1,764-lb st] *RD-20 turbojets. For the purpose of implementing this directive:*

1. Chief Designer of Plant No. 155 A. I. Mikoyan and Vice Chief Designer Gurevich are tasked with:

a) designing and constructing a single-seat fighter powered by two 1,000-kgp RD-21 turbojets or by two BMW 003S turbojets, possessing the following performance:

- *maximum speed at 5,000 m* [16,404 ft]*, 950 km/h* [513.5 kts]*;*
- *maximum speed at sea level, 920 km/h* [497.3 kts]*;*



Assembly of a MiG-9's rear fuselage in a jig.

• *climb time to 13,000 m* [42,651 ft], *12 minutes;*

• *range in economic cruise mode, 800 km* [497 miles]*;*

• *armament: one 45-mm and two 23-mm* [cannons].

The aircraft is to be built in two examples, the first of which is to enter flight test in April 1947.

b) they are to submit for State acceptance trials in September 1946 a fighter powered by two 800-kgp RD-20 engines, possessing the following performance:

• *maximum speed at 5,000 m, 910 km/h* [491.89 kts]*;*

• *maximum speed at sea level, 900 km/h* [486.48 kts]*;*

• *climb to 13,000 m, 14 minutes;*

• *range in economic cruise at 13,000 m, 600 km* [373 miles]*;*

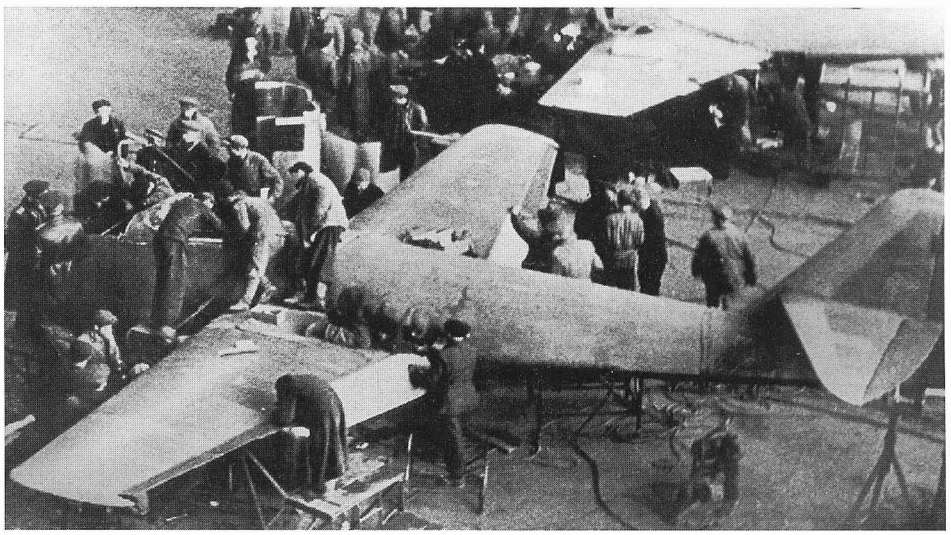
• *range in economic cruise at 10,000 m* [32,808 ft], 800 km [498 miles]*;*

• *armament: one 57-mm and two 23-mm* [cannons].

For the purpose of increasing the range of this aircraft by 100 km Chief Designer A. I. Mikoyan is tasked with equipping the 2nd example with external fuel tanks; the aircraft is to be submitted for State trials on 1st November 1946.'

On 7th July the modified machine with a reinforced heat shield made its 12th flight; surprisingly, the vibrations disappeared.

On the fateful day of 11th July 1946 a demonstration of new jet aircraft to senior MAP officials and top-ranking Soviet Air Force commanders was arranged at the LII airfield. It was attended by Minister of Aircraft Industry Mikhail V. Khroonichev, his deputy Pyotr V. Dement'yev, Commander-in-Chief of the Air Force Chief Air Marshal K. A. Vershinin, Chief Designers Aleksandr S. Yakovlev, Artyom I. Mikoyan and many other specialists. The aircraft on display included the first prototypes of the I-300 and the Yak-Jumo, as well as a captured example of the Heinkel He 162A (for comparison purposes).



The fighter takes shape.

LII test pilot Gheorgiy M. Shiyanov flying the He 162A was the first to perform a flying display, followed by Mikhail I. Ivanov in the Yak. Aleksey N. Grinchik in the I-300 was the third to take to the air. During the closing part of the programme the pilot decided to make a pass over the airfield at a low altitude (some 100 to 150 m/330 to 400 ft) at high speed (around 600 km/h; 324 kts). As the aircraft approached the airfield, two glittering objects were seen to separate from it; the machine rolled inverted, entered a dive and hit the ground on the outskirts of the airfield, exploding on impact. All that was left of the aircraft was a heap of twisted metal and a deep crater. This was the twentieth flight of the F-1; by the time of the crash it had logged 6 hours 23 minutes total time. The crash was traced to a failure of the attachment lugs of the detachable wing leading edge fairings; the fairings broke away, hitting and damaging the sta-

biliser, causing the aircraft to lose control and dive into the ground).

While the first flying prototype of the I-300 was undergoing flight tests, the second (F-2) and the third (F-3) prototypes were under construction at Plant No. 155; unlike the F-1, they had an entirely duralumin, not plywood, skinning. The second machine was completed in early May 1946, and on 11th May it was delivered to TsAGI for tests in the T-101 wind tunnel as arranged. In the course of these tests studies were made of the influence of the jet efflux on the aircraft's stability, on the vibrations of the aft fuselage and on the temperature conditions of the entire airframe. Besides, the research encompassed such issues as the functioning of the wing-mounted airbrakes, the dynamics of gas passage, and studies of the fighter's aerodynamics with external fuel tanks.

Later the F-2 was taken to the LII airfield to be brought up to flight status; interestingly, this happened on 11th July, exactly two months after the fighter's arrival at TsAGI – and on the very day when the first prototype crashed. The manufacturer's flight tests of the second prototype I-300 officially began on 8th August, and on 11th August the fighter made its first flight with Gheorgiy M. Shiyanov at the controls.

The third I-300 prototype joined the test programme in the first half of July. Chronologically, however, it was the second aircraft to fly, taking to the air on 9th August (two days before the first flight of the second prototype) in the hands of Mark L. Gallai, yet another LII test pilot. After Grinchik's demise both pilots, who had some experience of flying captured German aircraft, were assigned to the I-300 manufacturer's flight test programme by special orders issued within the Ministry of Aircraft Industry.

The very first flight in the F-3 was a sore trial for Gallai. Immediately after take-off the aircraft began to pitch up; attempts to level it off led to greatly increased stick forces which tended to become still greater when the elevator trim tab was activated. The pilot had the presence of mind to try and set the trim tab switch in reverse, after which the situation reverted to normal. (Later, it transpired that the wiring of the elevator trim tab control had been connected incorrectly during final assembly.) Still, it proved impossible to complete the mission in a dignified manner. The F-3 bit the dust (literally) on its first flight, albeit for a different reason: the nose gear unit broke away completely during the landing run, the fighter's nose scraping along the runway in a shower of sparks.

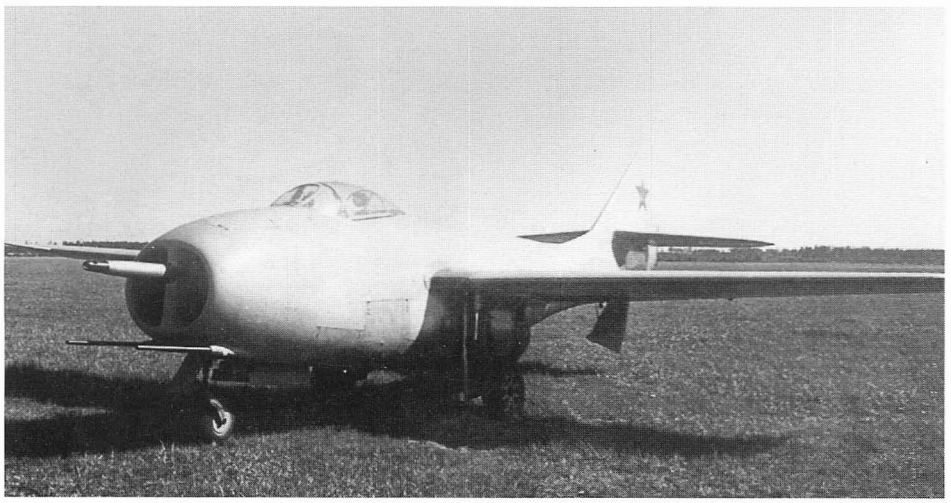
After the F-3 had been repaired, the tests resumed. It was this machine that bore the brunt of the manufacturer's flight test programme after the loss of the F-1. Gallai attained a maximum speed of Mach 0.8 in this aircraft. The same machine was used by the same pilot for tests which involved manoeuvring with the highest admissible G loads and for measuring top speeds at different altitudes. Concurrently with the testing of the F-3, G. M. Shiyanov on the F-2 measured the fighter's range and studied the I-300's ability to fly with one engine shut down. On 18th August 1946 he demonstrated the second I-300 prototype at the traditional air display in Tushino. The flight was performed at an altitude of 400 m (1,312 ft) in full view of the Government stands and spectators. The third prototype, the F-3, was also prepared for take-off on that day, to serve as a back-up aircraft.

The ten days that followed the flypast were used for making modifications to both aircraft and preparing them for further testing. Flights were resumed on the F-2 on 29th August, the F-3 following suit on 4th September. Along with fulfilling the initial flight test programme, the engineers and flight test facility personnel continued their search for methods of eliminating the recurrent vibrations by further increasing the rigidity of the heat shield and improving its attachment to the aircraft's fuselage.

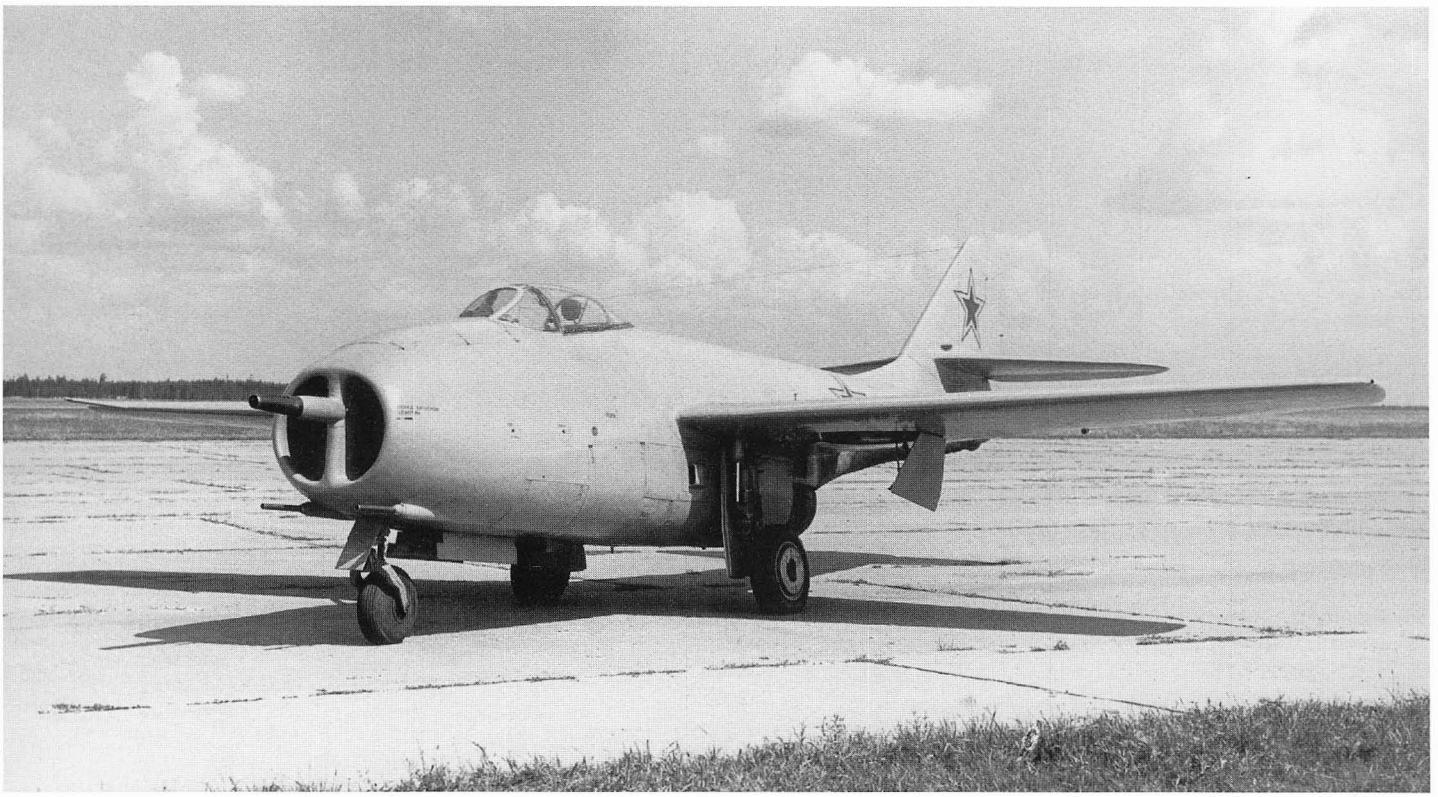
In the meantime, familiarisation of the military with the new jet aircraft went on. On 7th September a large group of Soviet Air Force (VVS – *Vo**yen**no-voz**doosh**nyye **see**ly*) generals and commanders from Air Force units arrived at the LII airfield to take part in a scientific and technical seminar devoted to the I-300 (F-2). On 27th September an order came in, stipulating that a group of test pilots from GK NII VVS be urgently trained to fly the I-300 for the purpose of participating in the flypast over Moscow's Red Square during the traditional military parade on 7th November. Bearing in mind the need to complete the aircraft's test programme, it was decided that conversion training of the military pilots would be conducted primarily on the second prototype, while the testing, as mentioned above, would be concentrated on the F-3.

In early October 1946 preparations were in hand for submitting the F-3 for State acceptance trials, but the machine's participation in the training for the 7th November parade prevented it from being handed over to GK NII VVS on time. Concurrently, redesigned wings developed in accordance with recommendations from TsAGI were fitted to the F-2; to this end a new set of detail drawings had been prepared by the OKB. Between 1st October and 12th November the second prototype was at the disposal of the VVS for training the pilots assigned for participation in the parade.

Above: Still in primer, the first production MiG-9 (*izdeliye* FS) is rolled out in Kiubyshev.



The second prototype I-300 (F-2) seen on an unpaved airfield at a late stage of its trials programme.



An early-production MiG-9 (*izdeliye* FS). The MiG-9 typically assumed a nose-high attitude on the ground. Note that the mainwheel well doors remain open when the landing gear is down.

As already mentioned in the introductory section, the leaders of the Soviet Union attached considerable importance to demonstrating new aircraft types at air displays. This was not only a means of publicising the scientific and military achievements of the USSR; it also demonstrated the nation's power to the outside world. Therefore, on 28th August 1946, when the manufacturer's flight tests of the I-300 were in full swing, the Ministry of Aircraft Industry issued order No. 581ss which stipulated:

'For the purpose of accelerating the production of the I-300 jet aircraft designed by Chief Designer A. I. Mikoyan and Vice Chief Designer Gurevich:

1. Director of plant No. 1 Litvinov and Chief Designer A. I. Mikoyan shall organise production of a small batch (10 examples) of the I-300 aircraft at plant No.1; the aircraft shall be completed in 1946.'

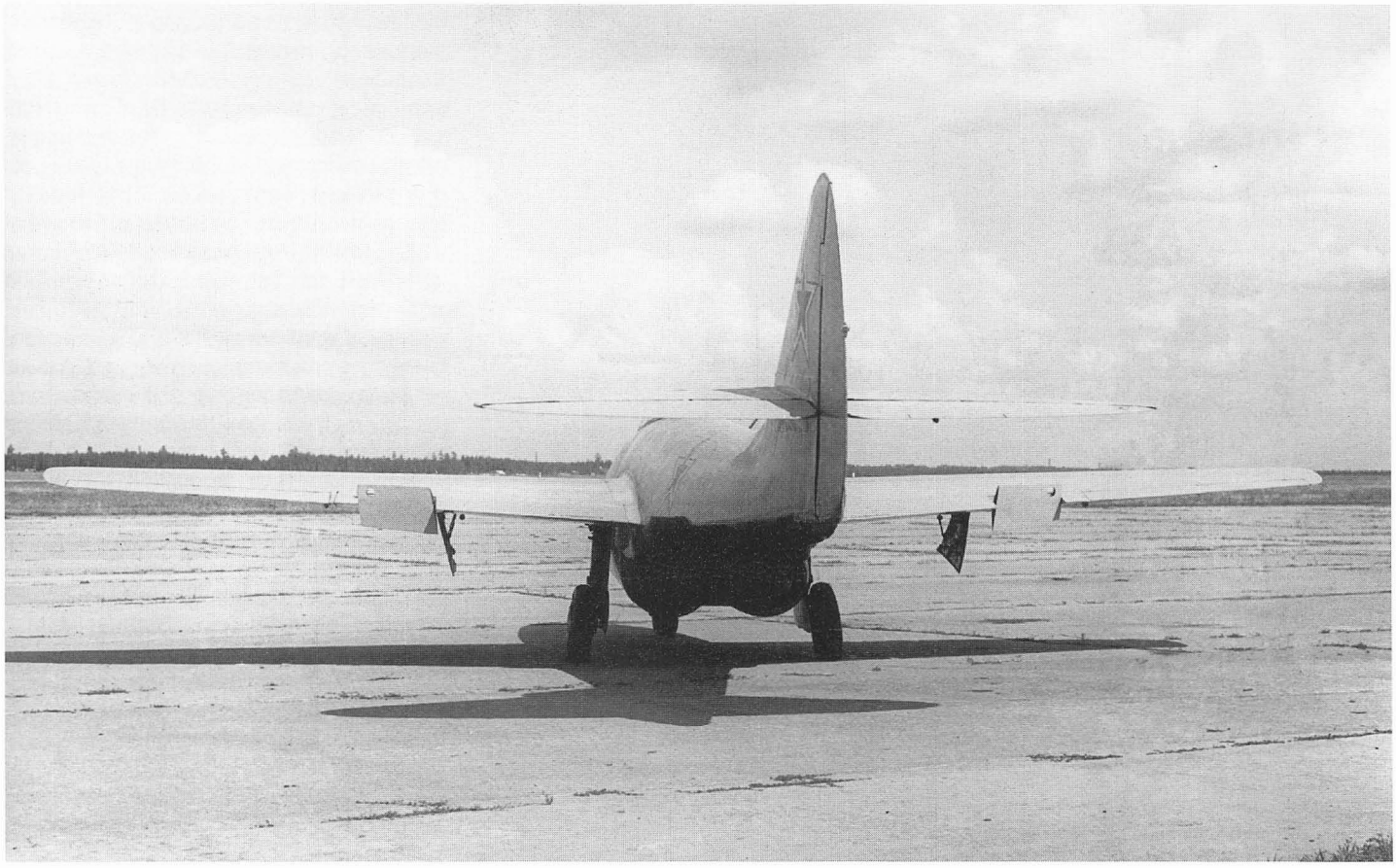
On 12th September MAP issued yet another order which required small batches of jet aircraft numbering from eight to 15 examples to be manufactured and flight-tested in advance of the flypast over the Red Square scheduled for 7th November (all this was to be done within just six weeks!). At least two production aircraft of each type were to be submitted to GK NII VVS for State acceptance trials. Still earlier, nearly a month before the issuance of this directive (on the following day after the Tushino air display of 13th August) Chief Designers A. I. Mikoyan and A. S. Yakovlev were summoned to the Kremlin where they received personal instructions from I. V. Stalin to the effect that 15 aircraft of each type (ie, I-300 and Yak-Jumo) be built for the purpose of their demonstration at the annual parade in Moscow's Red Square commemorating the anniversary of the Great October Socialist Revolution.

Thus, the decision to build, test and prepare for the November parade a small batch of I-300s was taken when the manufacturer's flight tests of the aircraft were not yet completed. Similar official decisions on the manufacture of small batches (10 to 15 machines) were taken in the respect of other prototype jet fighters designed by A. S. Yakovlev and S. A. Lavochkin immediately after the Tushino flypast. The initial-production I-300s (by then the type had been allocated the service designation **MiG-9**) were to be powered by BMW 003A engines, a small stock of which had been captured in Germany. Known in service as the RD-20 Series A1, these original German engines had a TBO of only ten hours. Subsequently the Kazan' engine factory No. 16 managed to increase the TBO of 50 hours; the longer-life Kazan'-built engines were designated RD-20 Srs A2.

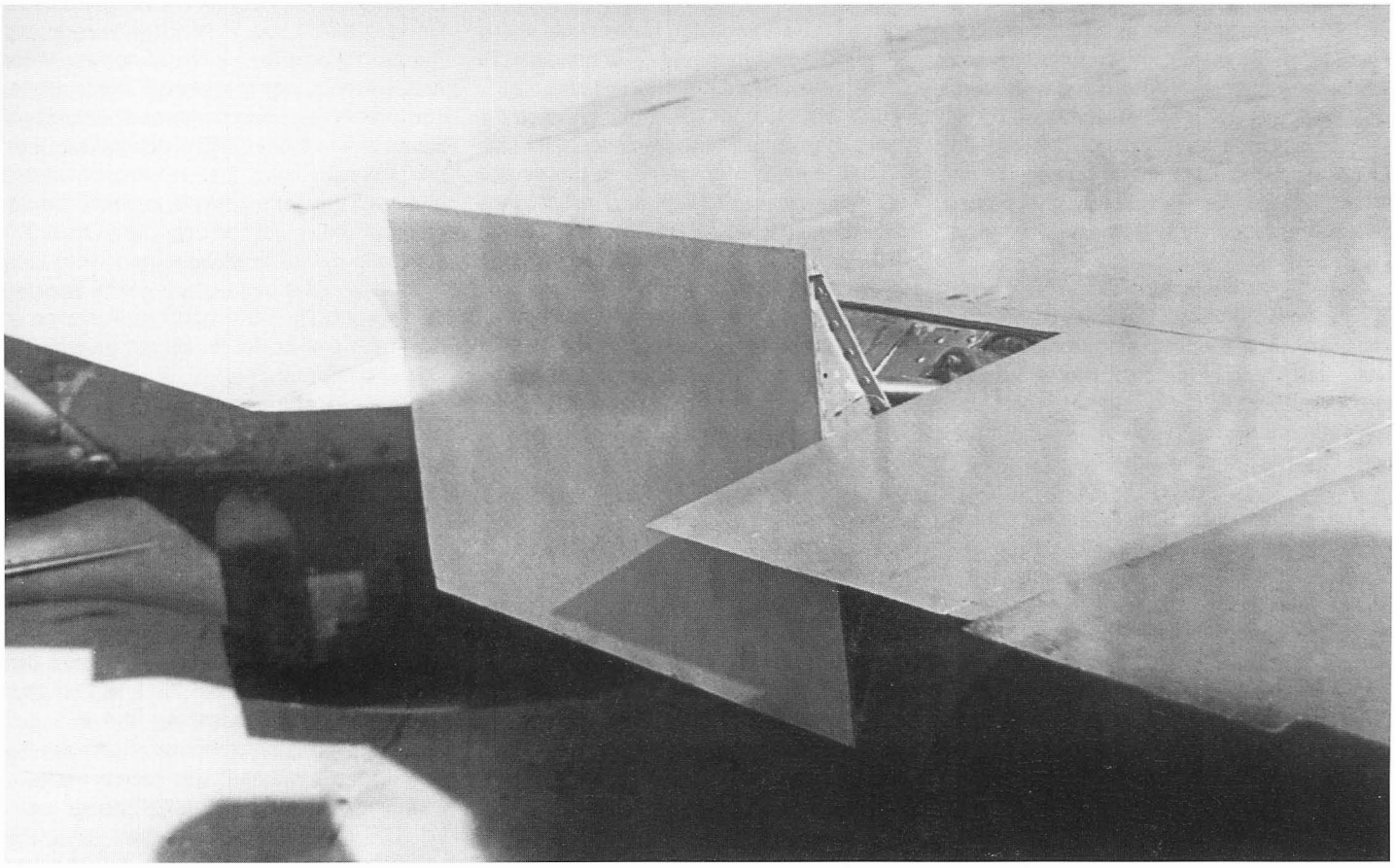
The time limits set for the manufacture of small batches of jet fighters seemed absolutely impracticable; nevertheless, all the plants did what they were expected to do. The first production MiG-9 (c/n 106001) was completed on 13th October; the remaining nine aircraft (c/ns 106002 through 106010) were assembled by 22nd October. All of them were virtually hand-made, next to no production tooling being available; structurally they were basically identical to the second and third prototypes. The fighters were transported to the airfield in Ramenskoye by rail, and as early as 26th October Mark L. Gallai flew the first production machine. In addition to Gallai and Shiyanov, production MiG-9s were flown by GK NII VVS test pilot L. M. Koovshinov; later, other military pilots selected for demonstrating the aircraft over the Red Square on 7th November joined in the conversion to jet fighters. Preparations for the aviation part of the military parade were fully completed, yet the flypast on that festive day had to be cancelled due to adverse weather.

In October, while military pilots were preparing for the anniversary parade, the final stage of the I-300's manufacturer's flight tests began, preceded by live weapons trials at a shooting range. Mark Gallai was tasked with testing the armament in the air. This was the most dangerous mission, since there was no prior experience in the USSR of large-calibre automatic cannons being fired in the air on jet aircraft. On 10th and 17th October Gallai performed flights to an artillery shooting range in Noginsk east of Moscow where he fired the weapons; these flights showed that the aircraft behaved normally when the 37-mm cannon mounted in the air intake splitter was fired.

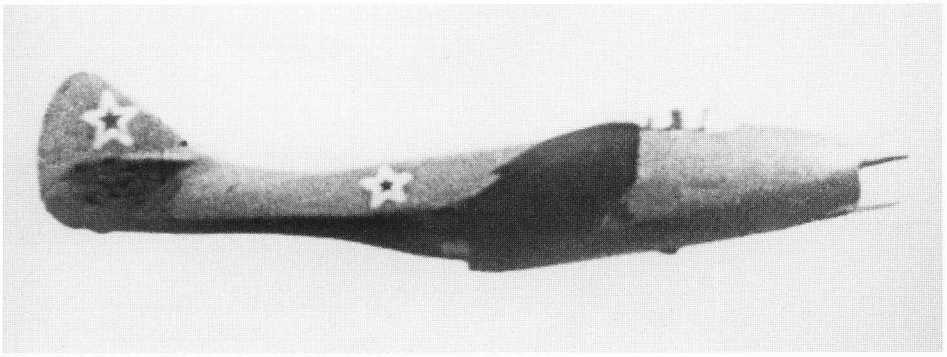
Above and below: Two views of a MiG-9 equipped with airbrakes built into the wing trailing edge just outboard of the flaps.



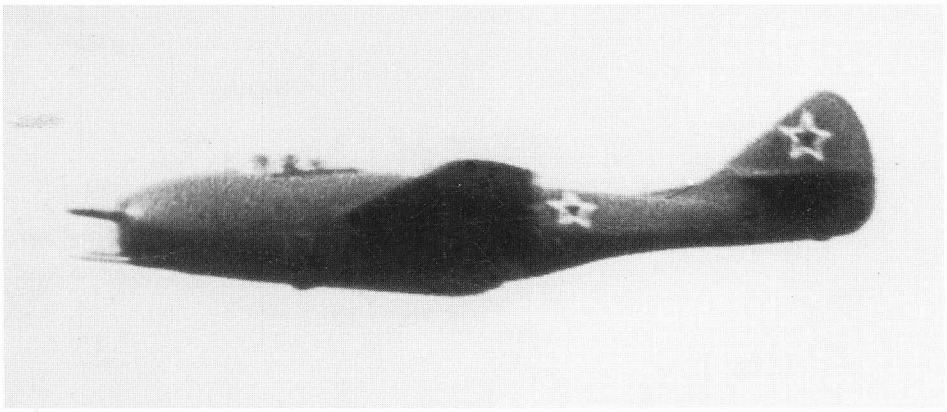
Above: Rear view of the MiG-9 with the airbrakes deployed.



The MiG-9's airbrakes were sections of the flaps designed to turn at right angles to the wing upper surface.



Above and below: stills from a ciné film showing the MiG-9 in flight.



Generally the performance figures obtained in the course of the I-300's manufacturer's flight tests were fairly impressive. The range at an altitude of 5,000 m (16,404 ft) and 563 km/h (304 kts) indicated airspeed was 633 km (393 miles), the endurance being 1 hour 2 minutes. With one engine shut down and the fighter flying at 360 km/h (194.6 kts) IAS, the maximum range at 5,000 m increased to 726 km (451 miles), the endurance being 1 hour 40 minutes. Remarkably, the aircraft showed no tendency to yaw when flying on the power of one engine.

When the manufacturer's flight tests were coming to an end, M. Gallai had a narrow escape on the F-3 when the horizontal tail disintegrated; the pilot had to muster all his skill to make it back to base and land the damaged aircraft in one piece. A while later, in February 1947, a similar accident happened on the F-2 flown by GK NII VVS test pilot Yuriy A. Antipov during the State acceptance trials – it also suffered a structural failure of the stabiliser. Fortunately, once again the pilot managed a safe landing. As a result, urgent steps had to be taken to reinforce the fighter's airframe and make some other improvements; both affected aircraft were repaired.

Manufacturer's flight tests of the F-2 went on through the second half of November and the first half of December; on 17th December the machine was handed over to GK NII VVS for State acceptance trials. The F-3 had been handed over to the military institute ten days earlier, on 7th December 1946. However, in accordance with the Council of Ministers directive No. 1249-511ss dated 5th June 1946 the I-300 (MiG-9) was to be presented for State acceptance trials as early as 1st September. Thus, the design bureau was nearly three and a half months late in handing the machines over to GK NII VVS. Later, in the autumn of 1946, the Government revised the State acceptance trials commencement date and the number of machines to be handed over was increased to four (they included the first two machines of the initial-production batch and the two surviving prototypes). However, bearing in mind the haste in which the small batch had been built in Kuibyshev, the transfer of the production fighters to GK NII VVS was delayed in order to subject the airframes to a more thorough check.

The State acceptance trials of the F-2 were interrupted on 5th April 1947 when test pilot D. G. Pikoolenko had to make a belly landing because of an engine failure. There were also other flight incidents. In one of the flights Pikoolenko discovered that the aircraft tended to pitch up in maximum-speed flight. Antipov decided to repeat the flight profile and get a personal impression of what had happened, but when the machine was flying at approximately 5,000 m (16,400 ft) the stabiliser suddenly disintegrated (this accident happened in February). In both cases the aircraft was saved thanks to the skill and courage of the pilots. Fortunately, in each case the pilots succeeded in landing the fighter safely at the risk of their lives, using ailerons for lateral control and 'playing' with the throttles for pitch control. This made it possible to trace the causes of the accidents and make appropriate changes to the tailplane design.

After repairs and necessary improvements had been made, the trials of the second prototype resumed on 21st May and were duly completed on 29th May. Somewhat earlier, on 19th May, the testing of the F-3 was completed, too. Between 2nd June and 24th June the institute held armament trials on the F-2; these were not part of the State acceptance trials programme.

State acceptance trials of the second production machine (c/n 106002) were started on 8th May 1947, continuing until 21st June. Testing of the first production MiG-9 (c/n 106001) which had passed manufacturer's flight tests with two 260-litre (57.2 Imp gal) drop tanks under the wingtips between 27th December 1946 and 5th April 1947, began on 28th April (also with drop tanks); on 8th May the fighter had to be grounded because its RD-20 engines had to be replaced but no replacement engines were available at the institute. The aircraft rejoined the State acceptance trials programme on 2nd June, this time in 'clean' configuration, completing them on 21 June together with the second production machine.

During the State acceptance trials the MiG-9 was flown by GK NII VVS test pilots A. G. Proshakov, A. Khripkov, A. G. Koobyshkin, Yu. A. Antipov, P. M. Stefanovskiy and D. G. Pikoolenko, while Engineer-Major A. S. Rozanov was in charge of the machine. The military test pilots performed hundreds of flights on the four jet MiGs, determining their performance, firing the weapons, studying and evolving the methods of their combat employment in first-line units. More than 200 aerobatic manoeuvres were performed and there was not a single case of the engines flaming out. The I-300 has the distinction of being the first Soviet jet aircraft on which a spin was performed.

The use of four machines was due primarily to the wide scope of the trials programme which could not be effected within a short time frame on one or two aircraft. Thus, the F-2 (or MiG-9 No. 02, as it was referred to in the GK NII VVS report) was used between 17th December 1946 and 5th April 1947 for determining the stability and handling characteristics, as well as field performance with American-made wheels borrowed from a Bell P-63 Kingcobra. Between 7th and 21st May 1947 the institute assessed the changes made by the manufacturer when updating the aircraft; the armament was tested between 2nd and 24th June 1947, having been installed immediately prior to that.

Kuibyshev-built MiG-9 c/n 106002 was used in May and June 1947 for determining

the range and endurance, as well as field performance with Soviet-made wheels, and assessing the functioning of the radio equipment. MiG-9 c/n 106001 served for assessing the fighter's agility, aerobatic capabilities and structural strength limits in June 1947. The F-3 (or aircraft No. 03) was used for determining the speed limits and basic flight performance (with the exception of range and endurance). Besides, in July-December 1947 the fifth aircraft of the 'parade' batch (MiG-9 c/n 106005) was used by GK NII VVS for special tests involving mock combat with the Lavochkin La-9, Bell P-63C Kingcobra, Supermarine Spitfire Mk IX and Yak-15. The fourth aircraft of the initial batch (MiG-9 c/n 106004) underwent State acceptance trials to determine the influence of firing the weapons on the engines' operation at altitudes in excess of 7,000 m (22,965 ft); more will be said about this a while later.

The concluding part of the report on the State acceptance trials of the MiG-9 aircraft powered by RD-20 engines (signed by Soviet Air Force Commander-in-Chief, Air Marshal K. A. Vershinin and the Air Force's Chief Engineer N. Markov) ran as follows:

'1. The following basic performance characteristics have been obtained:

Maximum speed (never-exceed speed), km/h (kts)	*894* (483.24)
at 5,000 m [16,400 ft]	*910* (491.89)
Climb time to 5,000 m , minutes	*4.3*
Range, km (miles):	
at 5,000 m and 0.45 V_{max}	*705* (438)
at 10,000 m [32,800 ft] *and V_{max}*	*800* (497)
Endurance, hours/minutes:	
at 5,000 m and 0.45 V_{max}	*1 h 35 m*
at 10,000 m and V_{max}	*1 h 25 m*
Take-off run, m (ft)	*950* (3,116)
Landing run, m (ft)	*1,060* (3,477)

2. Deficiencies discovered:

- *the engines flame out when all three cannons are fired at altitudes in excess of 7,000 m;*
- *the aircraft has no ejection seat which precludes the possibility of the pilot bailing out at flight speeds in excess of 500 km/h* [270.27 kts];
- *the aircraft is not equipped with airbrakes, which makes a prolonged dive or a dive at a steep angle impossible;*
- *the cockpit is not provided with armour protection for the pilot;*
- *the 660 x 160 mm* [25.74 x 6.24 in.] *tires installed are not durable enough;*

MiG-9 specifications

	I-300	**I-300 (F-1, F-2, F-3)**	**MiG-9 (F-1, F-2, c/n 106001, c/n 106002)**
	As per CofM directive (February 1945)	**Manufacturer's flight tests**	**State acceptance trials**
Powerplant	2 x BMW 003	2 x BMW 003 (RD-20)	2 x RD-20
Thrust, kgp (lb st)	2 x 800 (2 x 1,764)	2 x 800 (2 x 1,764)	2 x 800 (2 x 1,764)
Length (without armament)	-	9.75 m (31 ft 11.85 in.)	9.75 m (31 ft 11.85 in.)
Wing span	-	10.0 m (32 ft 9.7 in.)	10.0 m (32 ft 9.7 in.)
Stabiliser span	-	3.75 m (12 ft 3.63 in.)	3.75 m (12 ft 3.63 in.)
Wing area, m^2 (sq ft)	-	18.2 (195.7) [2]	18.2 (195.7)
Empty weight, kg (lb)	-	3,165 (6,977)	3,193 (7,039)/ 3,533 (7,788) [8]
All-up weight, kg (lb)	-	4,988 (10,996)	5,054 (11,142)/ 4,988 (10,996) [8]
Fuel load, kg (lb)	-	1,320 (2,910)	1,378 (3,038)/ 1,298 (2,861) [8]
Top speed, km/h (kts):			
at sea level	900 (486.48)	n.a.	864 (467.0) [9]
at 4,500 m (14,760 ft)	-	n.a.	911 (492.43) [9]
at 5,000 m (16,400 ft)	910 (491.89)	920 (497.3) (M=0.78) [3]	910 (491.89) [9]
at 7,100 m (23,288 ft)	-	882 (476.75) (M=0.79) [4]	n.a.
at 10,000 m (32,800 ft)	-	n.a.	853 (461.0) 11
Time to height, minutes:			
to 5,000 m	-	5.35/6.5 [5]	4.3 [9]
to 10,000 m	-	13.7 [5]	10.8 [9]
Rate of climb, m/sec (ft/min)			
at sea level	-	18.5 (3,640.8)	22.0 (4,329.6) [9]
at 5,000 m	-	14.1 (2,774.8)	17.4 (3,424.3) [9]
Service ceiling, m (ft)	13,000 (42,651)	11,700 (38,385) [6]	13,500 (44,291) [9]
Maximum range, km (miles):			
at 1,000 m (3,280 ft)	-	n.a.	430 (267)/550 (342) [7]
at 5,000 m	-	633 (393)/726 (451) [7]	605 (376)/705 (438) [7]
at 10,000 m	500 (311) [1]	810 (503)/n.a. [7]	800 (497)/n.a. [7]
Endurance:			
at 1,000 m	-	n.a.	45 min/1 hr 13 min [7]
at 5,000 m	-	1 hr 2 min/1hr 40 min [7]	1 hr 4 min/1 hr 34 min [7]
at 10,000 m	-	1 hr 20 min/n.a. [7]	1 hr 21 min/n.a. [7]
Take-off run, m (ft)	-	895 (2,936) 9	920 (3,018)/ 950 (3,116) [10]
Landing run, m (ft)	-	n.a.	950 (3,116)/ 1,060 (3,477) [10]
Armament	1 x 57 mm	1 x N-57 w. 20 rounds	1 x NS-37 w. 40 rounds
	2 x 23 mm	2 x NS-23 w. 60 rpg	2 x NS-23 w. 80 rpg

Notes:

1. According to OKB-155 specifications for 1945 the range was to be 800 km (497 miles) at maximum speed and 600 km (373 miles) at 0.45 $V_{max.}$

2. In some documents the wing area of the I-300 prototypes is quoted as 18.8 m2 (202.15 sq ft).

3. Top speed of the F-1 aircraft at an all-up weight of 4,300 kg (9,480 lb).

4. Top speed of the F-3 aircraft at an all-up weight of 4,350 kg (9,590 lb).

5. Rate of climb of F-2 and F-3 aircraft at an all-up weight of 4,300 kg (9,480 lb), disregarding take-off run and acceleration/including take-off run and acceleration.

6. The maximum altitude attained by aircraft F-1.

7. On the power of two engines/one engine.

8. Aircraft F-3/MiG-9 c/n 106001.

9. Aircraft F-3.

10. Aircraft F-3/MiG-9 c/n 106002 (the F-3's take-off run and landing run are quoted for an AUW of 4,950 kg (10,912 lb) and a landing weight of 3,760 kg (8,289 lb) respectively.

• the aircraft is fitted with non-self-sealing kerosene tanks which develop leaks shortly after the beginning of operational service;

• the aircraft lacks a fire suppression system.

3. Besides the mentioned defects, a significant shortcoming inherent in the design of the MiG-9 aircraft has been brought to light. This shortcoming consists in the employment of an excessively high wing loading (275 kg/m²) [56.46 lb/sq. ft] *for the purpose of achieving the highest possible speed, given the limited available engine thrust; this has led to a deterioration of the aircraft's manoeuvrability and field performance.*

Due to this, the La-9, Kingcobra, Spitfire Mk. IX and Yak-15 aircraft enjoy an advantage over the MiG-9 in horizontal and vertical manoeuvring during aerial combat.

The long take-off and landing run of the MiG-9 necessitates its use from special airfields, thus limiting its employment as a tactical fighter.'

The report signed on 20th May 1948 noted that simultaneous firing of all cannons was impossible without special blast suppressors and that '...the MiG-9 aircraft can be used by Air Force units only after elimination of the defects'. On the credit side, the State commission noted that '...on the whole, the aircraft's handling qualities make it simple, pleasant, not tiresome to fly and easy to master'.

The specifications of the MiG-9 fighter are detailed in the table on the preceding page.

The table on this page (taken from the MiG-9's State acceptance trials protocol) shows how the MiG-9 rated against other fighters tested by GK NII VVS in 1945-47.

Still, despite the numerous shortcomings and defects, the MiG-9's assessment by the State commission can be considered favourable. Generally the military were quite pleased with the fighter's handling qualities; as for speed, rate of climb at high altitudes and altitude performance, it was markedly superior to piston-engined fighters then in service with the Soviet Air Force. Also, the MiG-9 had no equals in the Soviet Union regarding its firepower – the other contenders from A. S. Yakovlev's OKB-115 (the Yak-15) and S. A. Lavochkin's OKB-301 (the '150') were armed with only two 23-mm cannons (on the other hand, their engines did not flame out when the cannons were fired, whereas much work was still needed to enable the MiG-9 to actually produce a high weight of fire). In comparison with the Me 262 Mikoyan's fighter had a lower take-off weight and

	MiG-9	**Yak-15 No. 02, No. 15** [1]	**Me 262A-1a WNr 110 426**	**La-9** [2] **prototype**	**Yak-9** [3] **c/n 01-04**
Trials completion date	June 1947	April 1947	November 1945	October 1946	August 1946
Powerplant	2 x RD-20	1 x RD-10	2 x Junkers Jumo 004B	1 x Shvetsov ASh-82FN	1 x Klimov VK-107A
Normal all-up weight, kg (lb)	4,998-5,054 (11,018-11,142)	2,638-2,742 (5,815... 6,045)	6,026 (13,284)	3,425 (7,552)	3,222 (7,105)
Wing loading, kg/m² (lb/sq. ft)	274-278 (56.16-56.97)	177-185 (36.28-37.9)	280 (57.38)	194 (39.83)	188 (38.6)
Top speed, km/h (kts):					
at sea level	864 (467.0)	700 (378.37)	780 (421.62)	640 (345.94)	582 (314.59)
at 5,000 m (16,404 ft)	910 (491.89)	786 (424.86)	841 (454.59)	664 (358.92)	657 (355.13)
at 10,000 m (32,808 ft)	853 (461.0)	735 (397.30)	834 (450.81)	n.a.	610 (329.73)
Time to height, minutes:					
to 5,000 m (16,404 ft)	4.3	4.8	4.2	4.7	4.8
to 10,000 m (32,808 ft)	10.8	13.8	12.9	16.8	15.0
Maximum range, km (miles):					
at 1,000 m (3,280 ft)	550 (341)	300 (186)	n.a.	1,735 (1,077)	890 (553)
at 5,000 m (16,404 ft)	705 (437.8)	454 (282)	680 (422)	1,665 (1,034)	660 (410)
at 10,000 m (32,808 ft)	800 (496.8)	510 (317) at 8,000 m (26,246 ft)	n.a.	n.a.	n.a.
Endurance:					
at 1,000 m	1 hr 13 min	39 min	n.a.	4 hrs 30 min	2 hrs 49 min
at 5,000 m	1 hr 34 min	59 min	1 hr 5 min	3 hrs 20 min	1 hr 21 min
at 10,000 m	1 hr 21 min	1 hr 4 min at 8,000 m (26,246 ft)	n.a.	n.a.	n.a.
Take-off run, m (ft)	950 (3,116)	600 (1,968)	1,025 (3,362)	345 (1,132)	375 (1,230)
Landing run, m (ft)	1,060 (3,477)	530 (1,738)	1,075 (3,526)	490 (1,607)	550 (1,804)
360° turn time at 500 m (1,640 ft), seconds	37-39	26	n.a.	30	n.a.
G limit	+2.5-2.85	+2.9	n.a.	+2.7	n.a.
Armament (cannons)	1 x 37-mm (1.45 cal.) w. 40 rounds 2 x 23-mm (.90 cal.) w. 80 rpg	1 x 23-mm (.90 cal.) w. 60 rounds	4 x 30-mm (1.18 cal.) w. 90 rpg	4 x 23-mm w. 300 rounds	1 x 20-mm w. 120 rounds 2 x 12.7-mm w. 150 rpg

Notes:

1. Ie, the second and 15th production Yak-15s (c/ns 31002 and 31015).

2. Based on the test results of the 'aircraft 130' prototype.

3. Based on the test results of one of the prototypes of the Yak-9P fighter (the Yak-9 VK-107A with metal wings).

surpassed the German jet virtually in all performance characteristics except range. The British Gloster Meteor F.3 and the American Lockheed P-80A Shooting Star which had been designed and built somewhat earlier were also inferior in performance to the MiG-9 (again with the exception of range). A while later, improved versions of the Western fighters outperformed the Mikoyan twinjet, but that was achieved primarily thanks to the installation of more powerful engines (the Soviet Union was still seriously lagging behind the Western world in aero engine design at the time). As regards the armament, the MiG-9 was roughly on a par with the Meteor (the latter was armed with a quartet of 20-mm cannons) but could not use the armament with the same efficiency (the Meteor's wing-mounted engines could not possibly flame out when the cannons were fired in a salvo). The Shooting Star, on the other hand, was considerably inferior to the Soviet fighter as regards weight of fire (it was armed with six 12.7-mm machine-guns), but, again, it could fire its weapons without any limitations, since the six 12.7-mm (.50 calibre) machine-guns did not have such a marked effect on engine operation.

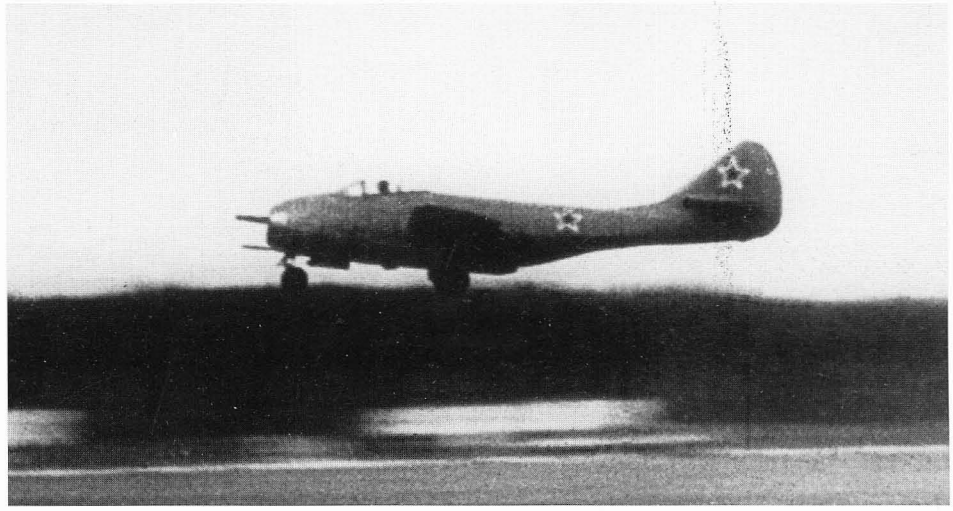
The table on this page gives a performance comparison of the Soviet, British and American fighters.

Despite obvious shortcomings and defects, full-scale production of the MiG-9 began at Plant No. 1 in Kuibyshev when the State acceptance trials were still under way. The production version was known in-house at OKB-155 as the **I-301**, aka *izdeliye* FS, the S standing for *se**reey**noye* (production, used attributively). The haste with launching production was again due to the wish of the nation's leaders to demonstrate the country's air power at the 1947 May Day parade. Besides, the Soviet government strongly believed that for want of something better one should build in series aircraft that were available at the moment and rectify their shortcomings in the process of production.

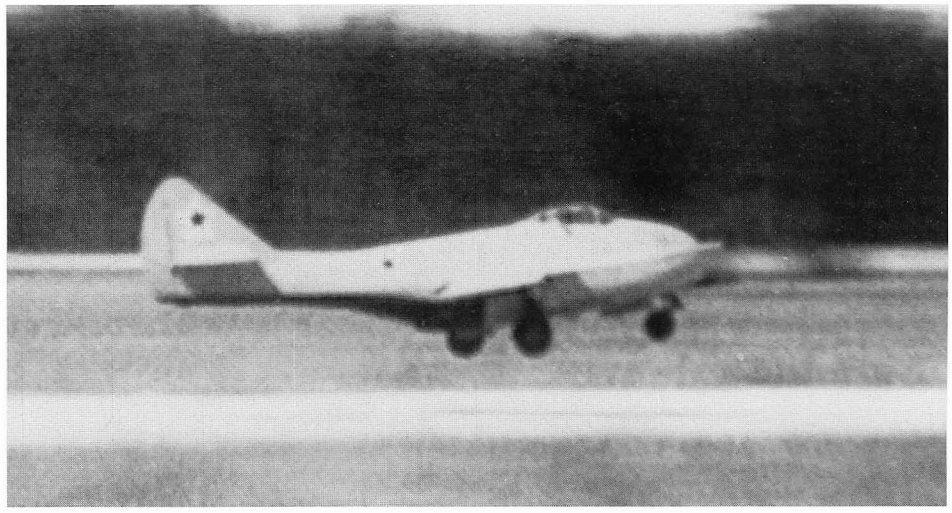
As noted earlier, the majority of production MiG-9s were powered by RD-20 Srs A2 engines built by the Kazan' engine factory No. 16. The armament of production fighters comprised one N-37 cannon and two NS-23K cannons. In March and April a batch of 48 aircraft intended for the May Day parade was manufactured, supplemented by one more machine for OKB-155, whereupon series production of the MiG-9 was suspended. Building on recommendations from TsAGI and the results of the manufacturer's flight tests and State acceptance tests, the OKB introduced a number of changes into the fighter's design in May and June 1947. The fuel system was improved; airbrakes were incorporated into the wing trailing edge just outboard of the

Performance comparison of first-generation jet fighters

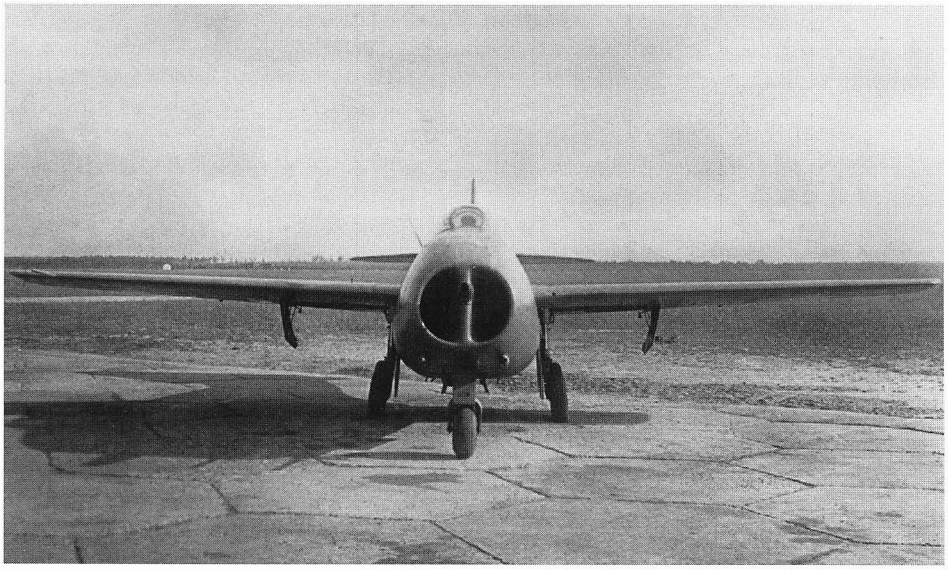
	MiG-9 (*izdeliye* FS)	Gloster Meteor F.3	Lockheed P-80A Shooting Star
Year of first flight	1947	1944	1944
Powerplant	2 x RD-20	2 x Rolls-Royce W.2B/37 Derwent 1	1 x Allison J33-A-17
Thrust, kgp (lb st)	2 x 900 (2 x 1,984)	2 x 907 (2 x 2,000)	1 x 1,750 (3,858)
Length overall	9.75 m (31 ft 11.85 in.)	12.6 m (41 ft 4 in.)	10.51 m (34 ft 6 in.)
Wing span, m (ft)	10.0 m (32 ft 9.7 in.)	13.11 m (43 ft 0 in.)	12.9 (42 ft 3.87 in.)
Wing area, m² (sq ft)	18.2 (195.8)	34.75 (373.9)	22.13 (238)
All-up weight, kg (lb):			
normal	4,998 (11,018)	6,050 (13,337)	6,350 (13,999)
maximum	n.a.	6,258 (13,795)	n.a.
Fuel capacity, litres (Imp gal)	1,595 (350.9)	n.a.	1,700 (374)
Maximum speed, km/h (kts):			
at sea level	864 (467.0)	n.a.	n.a.
at altitude	911 (492.43)	760 (410.81)	895 (483.78)
	(5,000 m/16,404 ft)	(9,000 m/29,520 ft)	n.a.
Rate of climb at S/L, m/sec (ft/min)	22.0 (4,329.6)	20.3 (3,995)	23.2 (4,565.76)
Service ceiling, m (ft)	13,500 (44,291)	12,800 (41,994)	n.a.
Maximum range, km (miles)	800 (497)	2,140 (1,329)	1,000 (621)
Armament	1 x N-37, 2 x NS-23	4 x 20-mm Hispano	6 x 12.7-mm Browning



A production MiG-9 takes off.



A MiG-9 just before touchdown.



Above: Head on view of a production MiG-9 at GK NII VVS during State acceptance trials.

Above: A three-quarters rear view of the same aircraft. Note the unusual location of the serial (22 Red) on the fin rather than on the nose.

Rear view of MiG-9 '22 Red'.

flaps. The fin area was increased and a fin fillet added to improve directional stability; also, the rudder and elevator skin which had been made of *elektron* magnesium alloy was replaced by duralumin and the framework of these control surfaces was strengthened. Air suction inside the fuselage was eliminated and the shape of the fuselage fairing aft of the engine nozzles was changed in order to ensure a smoother flow of engine exhaust gases.

In the course of three years a total of 610 MiG-9s was manufactured, 604 of them being production machines. As noted earlier, the first ten examples of the initial-production ('parade') batch were manufactured in great haste in 1946.

In the closing days of 1946 the Ministry of the Aircraft Industry issued order No. 801ss dated 26th December, which, referring to the Council of Ministers directive No. 2698-1114ss dated 16th December 1946, stated that:

'...Chief of the 10th Main Directorate Tarasevich and Director of plant No. 1 Litvinov shall:

a) manufacture and deliver to the Air Force 50 I-300 jet aircraft designed by Mikoyan and Gurevich, including 40 examples of the combat version and ten dual-control trainers...

b) ensure the manufacture of aircraft in accordance with the following schedule: five aircraft in January, 15 in February, 25 in March (including five with dual controls) and five aircraft with dual controls in April.'

The aircraft were intended primarily for participation in the May Day parade of 1947. In the spring of 1947 the prototype of the MiG-9's two-seat trainer version was just about to enter flight tests; as a result, in the long run it never entered production. Hence 48 single-seat MiG-9 fighters were completed in time for the parade; in accordance with the Council of Ministers directive No. 2698-1114ss of 16th December 1946 they were completed to the standard of the 11th production machine (ie, the first MiG-9 following the 'parade' batch of 1946), lacking armament. It was envisaged that they would be equipped with NS-23K cannons before 1st June 1948; as for the N-37 cannon, MAP specialists believed its installation in any fighter aircraft was out of the question before the weapon had been put through its paces. All 48 MiG-9s were displayed to good effect on the festive day as a part of the column of 100 jet aircraft. The 1947 production run at Plant No.1 totalled 292 single-seat aircraft.

The plan for 1948 called for the manufacture in Kuibyshev of 250 single-seat fighters and 60 two-seat UTI MiG-9s. On 25th December 1947 Chief Engineer of the Air Force N. Markov wrote to the Ministry of the Aircraft Industry, pointing out the need to urgently

incorporate a number of improvements into the MiG-9s on the production line; these included wing-mounted air brakes similar to those which had passed State acceptance trials on the second prototype of the trainer version (the FT-2) described later. In January 1948 Vice Minister of Aircraft Industry Pyotr V. Dement'yev issued instructions stipulating that from the 450th machine onwards the MiG-9 should be manufactured to the standard of a Batch 17 aircraft built in 1947, fitted with wing-mounted air brakes. Also in 1948 there were plans for fitting the fighter's cannons with devices intended to deflect the blast gases (beginning with the 380th airframe). From the 400th aircraft onwards the MiG-9 was to be fitted with combined airspeed indicators, Mach meters, fuel gauges and bulletproof windscreens.

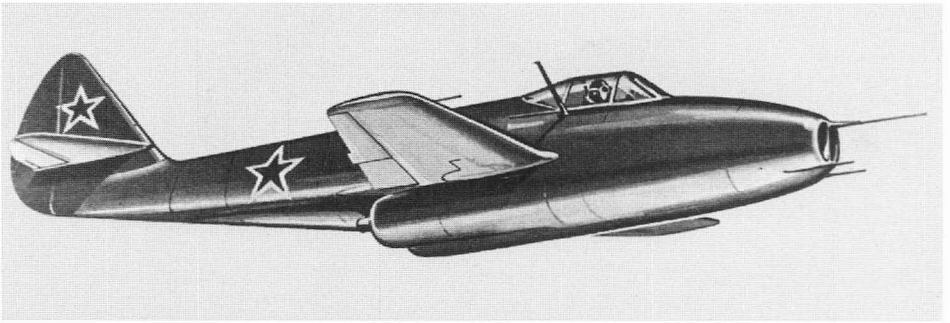
However, that year turned out to be very strenuous for the Kuibyshev aircraft plant, because already in the spring of 1948, concurrently with MiG-9 production, the plant had to start preparations for manufacturing the more advanced MiG-15. This was the main reason for the failure to incorporate many improvements into production MiG-9s; the dual-control version, no longer meeting the requirements of the day, was not built in quantity either – only combat aircraft rolled off the assembly line instead. As a result, 302 single-seat MiG-9s were manufactured in 1948. After that, production of the type was discontinued.

The leaders of OKB-155, Artyom I. Mikoyan and Mikhail I. Gurevich, were awarded the State Prize of the USSR for the creation of the first Soviet jet fighter. Mikoyan's jet firstling did not pass unnoticed in the West either. The NATO's Air Standards Co-ordinating Committee (ASCC) assigned the reporting name *Fargo* to the MiG-9; in the USA it was initially designated 'Type 1'.

According to information published in the press, production MiG-9s were operated by regiments of the 1st VA (*Voz**dooshn**aya* ***armiya*** – Air Army) based at Kobrin in Belorussia, the 7th VA (based near Dolliar railway station), the 14th VA based near the town of Gorodok (the name of which, ironically, itself means 'small town'), the 15th VA based near Kaliningrad and in the 16th VA stationed in East Germany (the unit operating MiG-9s was based near Berlin). In 1949 the MiG-9 was mastered by pilots of the 177th IAP (*istre**bitel'nyy** **avia**polk* – fighter regiment) of the 303rd IAD (*istre**bitel'naya** **aviadivee**ziya* – fighter air division) stationed in the vicinity of Yaroslavl'.

The year of 1950 saw the beginning of mass deliveries of Soviet combat aircraft to China, in parallel with the deployment of Soviet Air Force units to that country. Conversion of Chinese pilots to jet aircraft was organised, for which purpose MiG-9 fighters and Yak-17UTI fighter trainers were sent to China. One of the Chinese MiG-9s with the white tactical number '30' is on display at the Aviation Museum in Datangshan; another example (with no tactical number) is part of the collection of the People's Liberation Army Museum in Beijing.

An example of the MiG-9 coded 01 Red (c/n 114010) is on display in the Central Russian Air Force Museum in Monino. In the early 1960s this machine starred in a feature film called *They Conquered the Sky*.



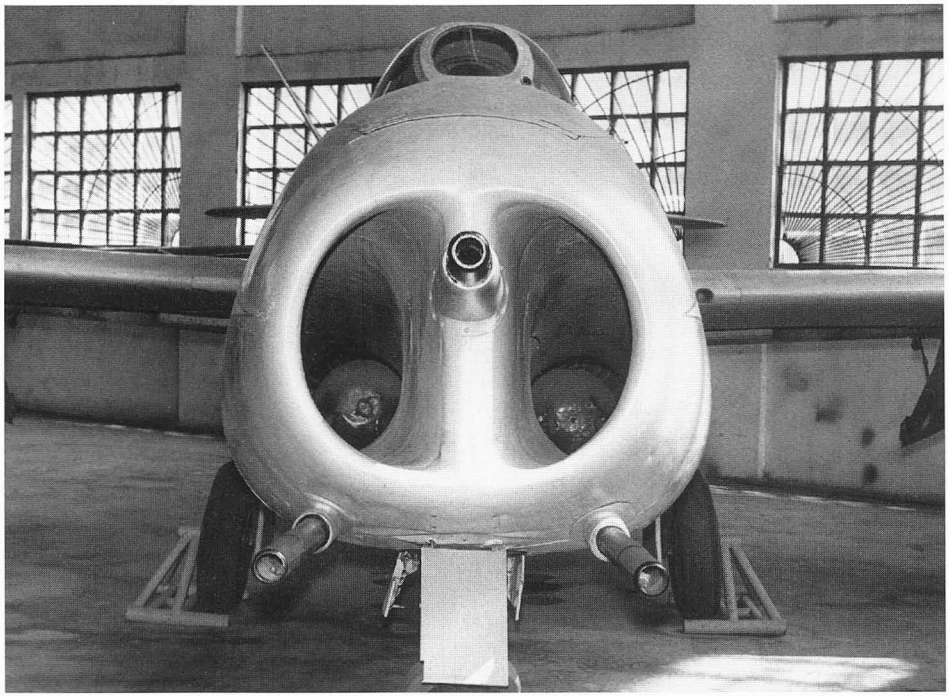
Above: An early artist's impression of the MiG-9 in *Jane's All the World's Aircraft*. Note that the main gear units are erroneously depicted as inward-retracting.

This MiG-9 painted with a white lightning bolt starred in the 1960s motion picture *They Mastered the Sky*.

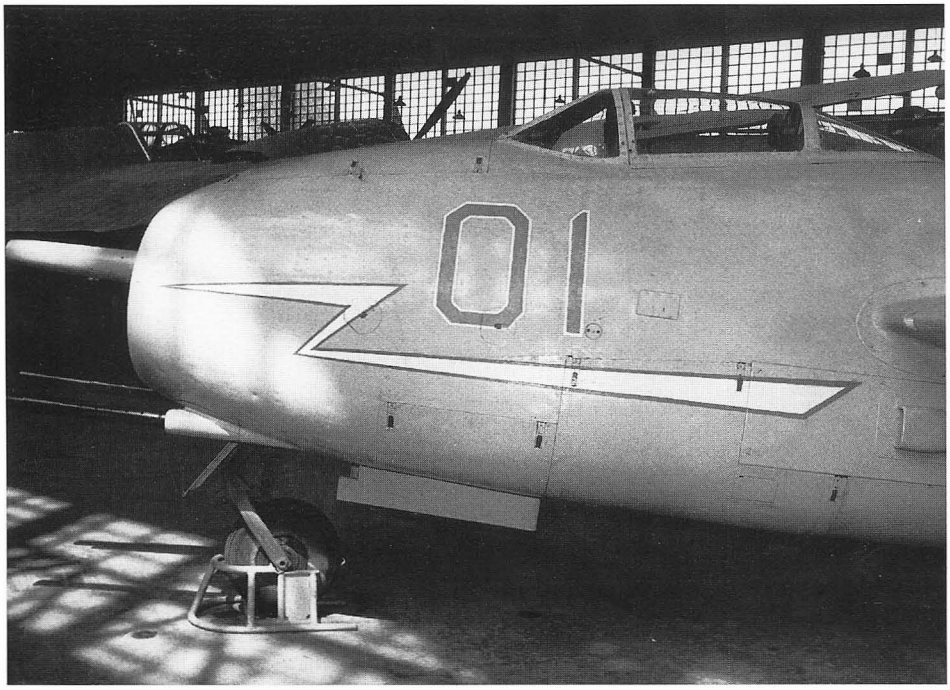
MiG-9 '01 Red' (c/n 114010) is preserved at the Central Russian Air Force Museum in Monino.

The production MiG-9 in detail

The MiG-9 was a cantilever mid-wing monoplane of all-metal construction with a smooth stressed skin and a retractable tricycle undercarriage. To simplify the process of assembly the aircraft was divided into several production units.



Above: Close-up of the MiG-9's air intake, showing the inlet ducts. The engines' compressor faces are blanked off.



The forward fuselage of MiG-9 c/n 114010. Originally the aircraft was stored indoors...

Fuselage: semi-monocoque stressed-skin structure. Duralumin was used as the main structural material.

Technologically the fuselage was built in two sections – the forward fuselage (frames Nos. 1 through 15a) and the rear fuselage (frames Nos. 15 through 35), which were joined together by fittings. The fuselage structure incorporated two air ducts supplying air to the engines. The ducts had an elliptic cross-section changing to circular at the rear and ran along the fuselage sides, flanking the cockpit.

The *forward fuselage* housed the armament, the nose landing gear unit, the cockpit with the canopy, controls and appropriate equipment, a fuel tank and other units. The forward fuselage framework consisted of four variable-section longerons, 15 frames, a number of stringers, two beams for the installation of the nose gear unit and two beams for the attachment of the armament. Attached to frame No. 1 was the front fairing which formed the aircraft's nose with a bifurcated air intake for the powerplant. The inlet ducts were structurally joined to the beams of the nose gear unit and to the armament attachment beams. Together with the floor of the cockpit, the skinning and the longitudinal structural members they formed a structure sustaining all the stresses of the forward fuselage.

The framework of the *rear fuselage* consisted of four longerons, 20 frames, a number of stringers and two ribs to which the main undercarriage units were attached. The aft fuselage housed equipment, wiring and control units, as well as two bag-type fuel tanks in containers. A heat shield protecting the fuselage undersurface from hot exhaust gases was mounted between frames Nos. 19 and 34. Between frames Nos. 19 and 29 the fuselage was structurally integral with the lower part of the fin. Lugs for mounting the stabilizers and the fin were installed on frames Nos. 32, 34 and 35.

The landing gear attachment ribs together with the wing attachment beam and engine attachment beam formed a load-bearing structure absorbing the loads from the undercarriage, the wings and the engines.

The cockpit was placed in the forward fuselage over the engines within the space between frame No. 5 and the sloping frame No. 11a. The cockpit canopy had a streamlined shape, consisting of a fixed windshield and an aft-sliding rear portion which could be jettisoned in an emergency. Aft of frame No.5 the cockpit floor was partly formed by the inlet ducts. The rear part of the floor adjoining the rear wall of the cockpit sloped in such a way that the pilot's seat was placed between the engines. The seat was a duralumin pan of the usual type, designed to accommodate a parachute and attached to the cockpit floor by brackets. The seat was provided with a harness comprising leg belts and shoulder straps. A padded seat back was attached to the rear cockpit wall. A padded headrest was attached to the rear bow of the sliding part of the canopy. The cockpit armour comprised two steel armour plates 12 mm (0.47 in.) thick and, on some machines, a 55-mm (2.16-in.) bulletproof glass plate mounted in the front part of the windshield. An attachment unit for the centrally-mounted cannon was installed in the cockpit on suitably stressed elements of the structure; the cockpit also housed the control stick and rudder pedals.

Wings: unswept wings of trapezoidal planform and all-metal two-spar riveted construction, built as one-piece panels attached to the fuselage sides. Incidence 1°, dihedral 2.5° and thickness-to-chord ratio 9% over the entire span.

The wings employed a combination of airfoil sections. A low-lift TsAGI 1-A-10 airfoil was used in the span segment between ribs Nos.1 and 3; a high-lift TsAGI 1-V-10 airfoil was used between rib No. 6 and the wingtip, and the span segment in between featured a transi-

tional airfoil section. This combination of airfoil sections precluded the possibility of the aircraft entering a spin at high angles of attack.

The wing framework comprised two spars, 21 ribs and a number of stringers. The wings were equipped with Frise ailerons and TsAGI-type slotted flaps (modified Fowler flaps). The flaps occupied the portion of the trailing edge between ribs Nos.1 and 11, the ailerons being accommodated between ribs Nos. 11 and No. 21. The ailerons' maximum deflection angle was +22.5°/–14.5°. The flaps were set at 20° for take-off and 50° for landing. The trailing-edge section of the wings between ribs Nos. 1 and 6 had a cut-out for the wheel wells. The wings also housed six bag-type fuel tanks which were placed in containers.

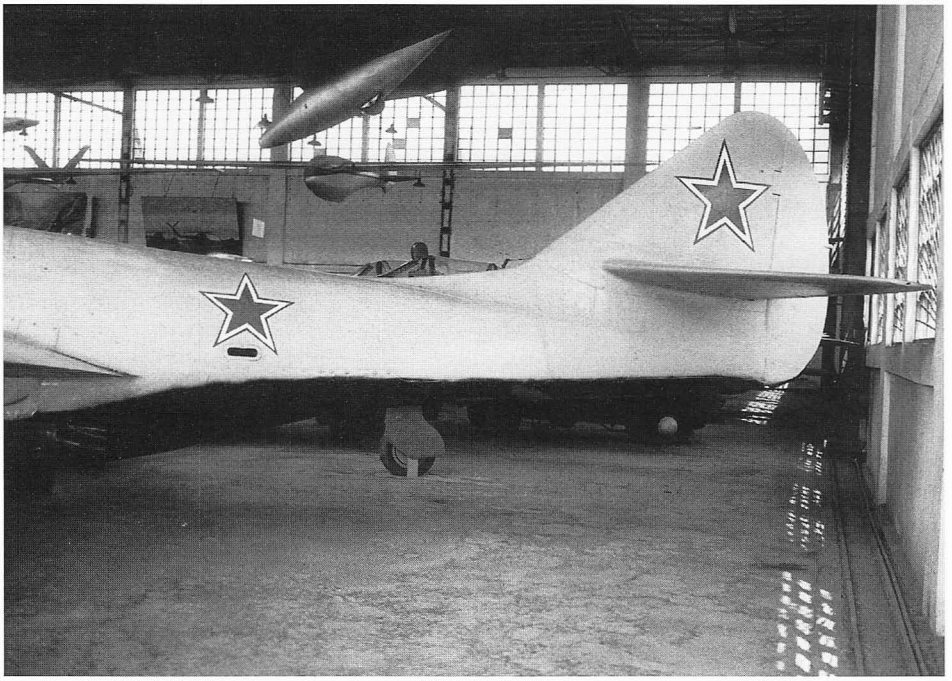
Tail unit: the empennage was of all-metal construction, featuring high-set cantilever stabilisers. The tail surfaces employed a NACA-0009 symmetric airfoil section. The fin and the stabilisers were detachable. The horizontal tail was built in two symmetrical halves, each half having two spars and 11 ribs. The front stabiliser attachment fittings were of a rack type, permitting the incidence of the stabilisers to be adjusted on the ground between the angles of +1°10' and –4°. The starboard elevator incorporated a steerable trim tab.

The fin structure was similar to that of the stabilisers. The fin's frame comprised two spars and six ribs. The elevators were of all-metal construction and were attached to the stabilisers by five brackets. The all-metal rudder was attached by three brackets to the fin and the fuselage.

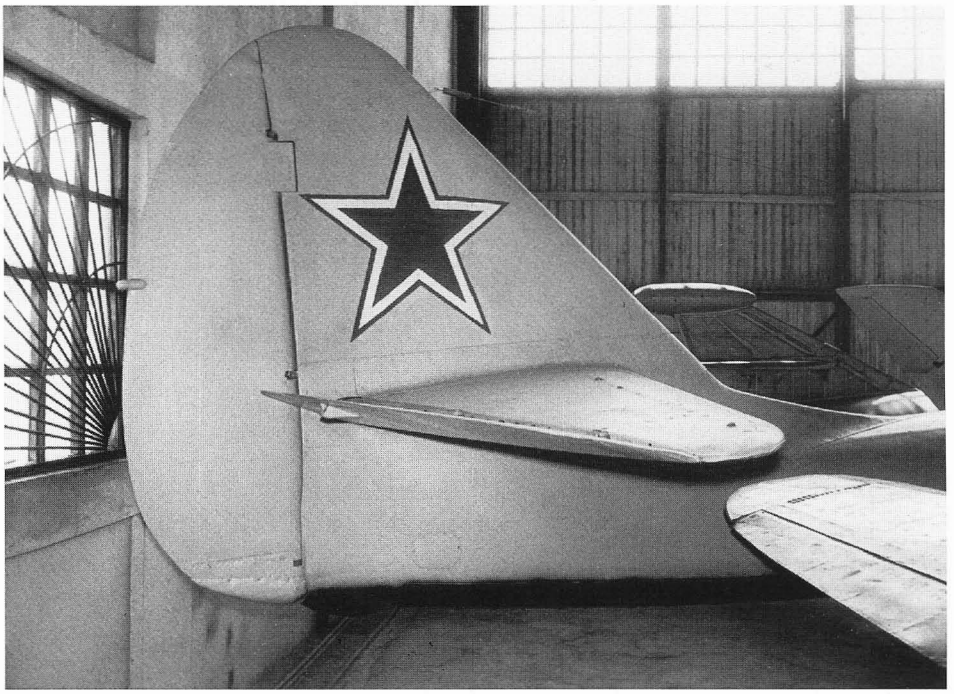
Landing gear: pneumatically retractable tricycle type, with single wheel on each unit. The wheel base was 3.02 m (9 ft 11 in.). All three units had levered suspension and oleo-pneumatic shock absorbers, those on the main undercarriage struts being mounted externally. The main units retracted outwards into the wings, the nose unit aft into the fuselage. The levered-suspension main units had 660 x 160 mm (25.74 x 6.24 in) wheels equipped with brakes and mounted on semi-forks. The nose unit had a non-braking wheel measuring 480 x 200 mm (18.72 x 7.8 in); it featured an attachment point, an integral shock absorber, a shimmy damper, an uplock, a downlock and a retraction jack. Each mainwheel well was closed by two doors, the bigger one being attached to the main gear strut and the smaller one to the wing; the nosewheel well had a forward door segment hinged to the nose gear oleo and two lateral doors at the rear.

Powerplant: two RD-20 Series A2 single-shaft axial-flow turbojets delivering 800 kgp (1,764 lb st) each. The engine had a seven-stage compressor, a single-stage turbine with air-cooled blades and a variable nozzle with a movable centrebody. Each engine had its own Riedel two-cylinder two-stroke starter.

The fuel (kerosene) was accommodated in ten tanks. Four tanks (including three bag-type tanks) were housed in the aft fuselage, the remaining six were located in the wings. The total capacity of the fuel system was 1,595 litres (351 Imp gal), of which 1,225 litres (269.5 Imp gal) could be carried in the four fuselage tanks. To facilitate engine start-up a special start-up fuel system using more easily combustible petrol was provided.

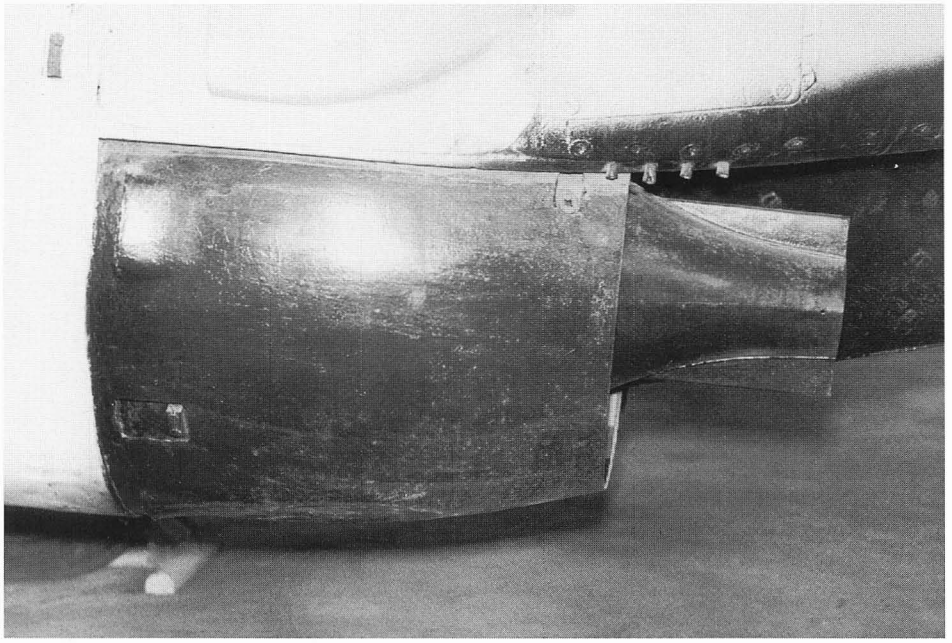


Above: The MiG-9's rear fuselage.

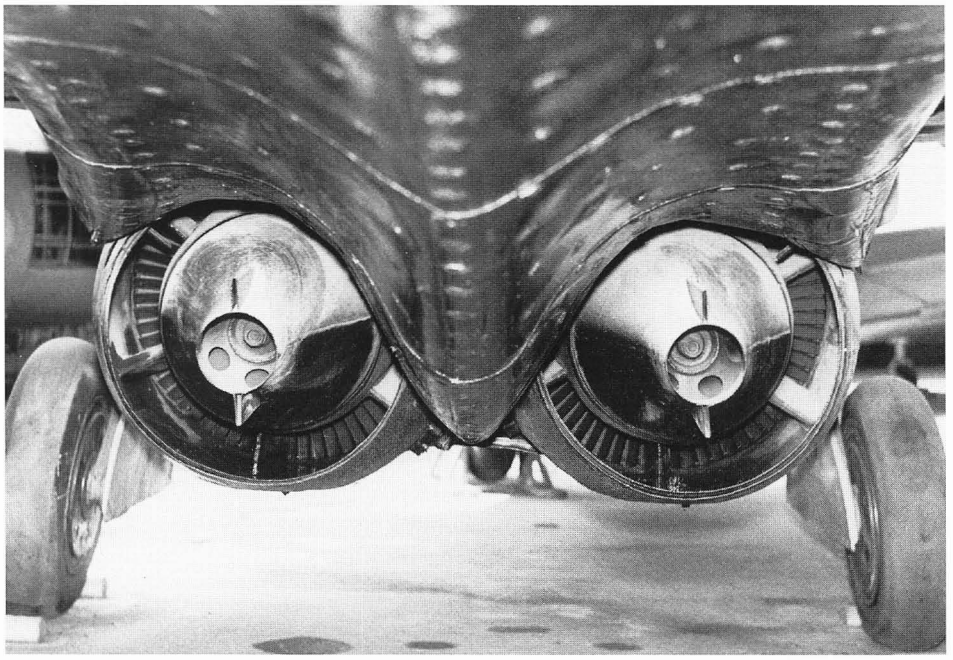


The tail unit. Note the shape of the fin fillet.

Armament: production MiG-9s were equipped with one centrally-mounted 37-mm (1.45 calibre) Nudel'man N-37 cannon with 40 rounds and two 23-mm (.90 calibre) Nudel'man/Sooranov NS-23K cannons with 80 rpg. The N-37 weighed 103 kg (227 lb) and possessed a rate of fire of 400 rounds per minute, the muzzle velocity of the shell being 700 m/sec (2,296 ft/sec). The NS-23K cannon had a rate of fire of 600 rounds per minute and a muzzle velocity of 680 m/sec (2,230 ft/sec). The N-37 protruded 1.16 m (3 ft 9.67 in.) beyond the plane of the air intake lip, while the



Above: The nozzle of the port RD-20 turbojet. Note the movable nozzle centrebody.



The hot end of the MiG-9, showing the turbine blades and the V-shaped steel heat shield.

NS-23K cannons protruded 0.5 m (1 ft 7.68 in.). The ammunition boxes were accommodated in an equipment bay between fuselage frames Nos. 1 and 6.

It should be noted that some production aircraft were provided with attachment points for a centrally-mounted cannon of a larger calibre. Thus, the first three machines of the 'parade' batch (c/ns 106001 through 106003) were provided with attachment points, ammunition box and link and case chutes for the 57-mm (2.24 calibre) Nudel'man N-57 (*izdeliye* 120P) cannon. MiG-9s with c/ns 106004 through 112001 were fitted only with attachment points for the N-57 cannon (they differed in having an increased-diameter internal bore).

Avionics and equipment: The basic range of equipment installed on production MiG-9s comprised the following items: an RSI-6 ('Rei-VM') short-wave transceiver; an RPKO-10M direction finder, a single 1.5-kilowatt GSK-1500 DC generator driven by one of the engines, a 12-A-10 DC battery and an RU-45A AC converter. The cockpit housed flight and navigation instruments and engine control instruments: a US-1000 airspeed indicator, a VD-12 altimeter, an electrical gyro horizon combined with a Horn-type turn indicator; a PDK-44 compass, a VR-30 vertical speed indicator, a TF-15 tachometer, an MP-80 kerosene pressure gauge, an EDMU-1 gas pressure gauge, a TVG-44 exhaust gas thermometer, a BE-296 fuel gauge and TME-45 engine oil thermometers.

A single-wire aerial was attached with one end to a strut which was mounted on a fuselage frame, offset to starboard; the other end of the aerial was attached to the fin.

The aircraft was fitted with a PKI-1 reflector gunsight which was later replaced by an ASP-1N optical sight; some machines were provided with an S-13 gun camera in the wing/fuselage fairing.

Oxygen system: a KP-14 breathing apparatus which ensured oxygen supply for the pilot to an altitude of up to 12 kilometres (39,370 ft).

Control system: conventional mechanical control system comprising control stick, rudder pedals and trim tabs. The stick was connected to the ailerons and elevators by push-pull rods and bellcranks, while the rudder was controlled by means of steel cables. The elevator trim tab installed on the starboard elevator was controlled electrically.

The table on page 46 compares the dimensions and performance characteristics of various versions of the MiG-9 fighter.

A number of prototype versions of the MiG-9 evolved from the baseline design. These are described below.

UTI MiG-9 (I-301T, *izdeliye* FT). In accordance with the Council of Ministers directive No. 1498-665s issued on 9th July 1946 the OKB-155 set about developing a two-seat trainer version of the MiG-9 which would be used for conversion training of Air Force pilots assigned to flying the single-seat jet fighter. On 6th August 1946 the Ministry of Aircraft Industry issued an appropriate order No. 525s which stated:

'Pursuant to the Council of Ministers directive No. 1498-665s of 9th July 1946 on the development of dual-control trainers which are needed for converting the flying personnel of fighter units to new jet aircraft:

1. Chief Designers A. S. Yakovlev and A. I. Mikoyan shall each develop, build and submit for State acceptance trials a single prototype of the following two-seat jet-powered aircraft based on single-seat fighters currently in production:

- *a Yakovlev-designed fighter powered by a Jumo 004 (RD) engine; it is to be submitted for State acceptance trials by 1st November 1946;*
- *a Mikoyan-designed fighter powered by two BMW 003 (RD-20) engines; it is to be submitted for State acceptance trials by 1st January 1947.*

2. Two-seat conversion and proficiency trainers shall have the same field performance

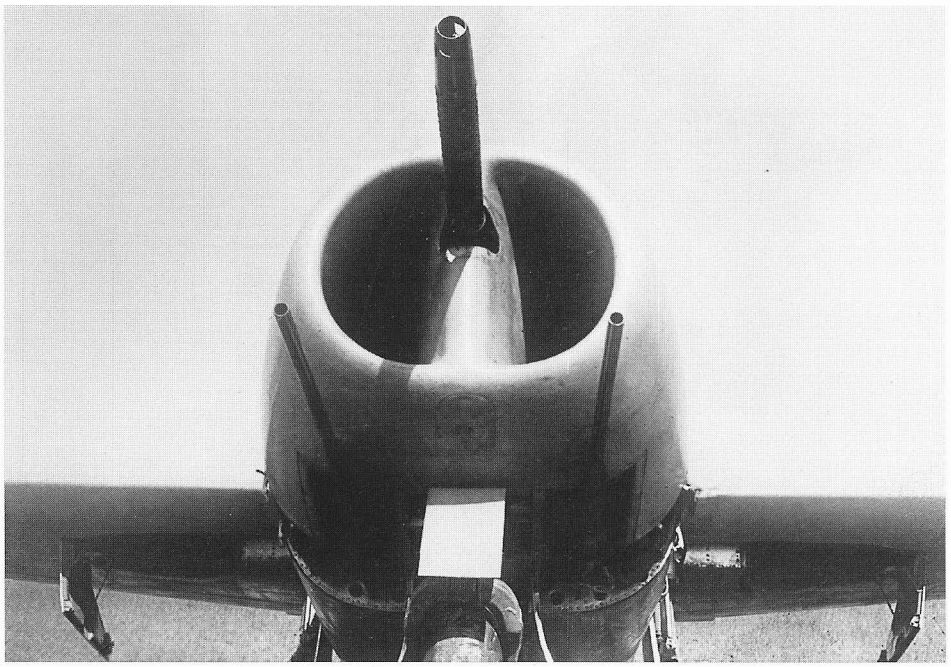
as the respective single-seat combat aircraft. Both cockpits shall be fully equipped so as to permit flying the aircraft. Trainer aircraft may have a reduced weapons fit and, if necessary, a lower top speed.'

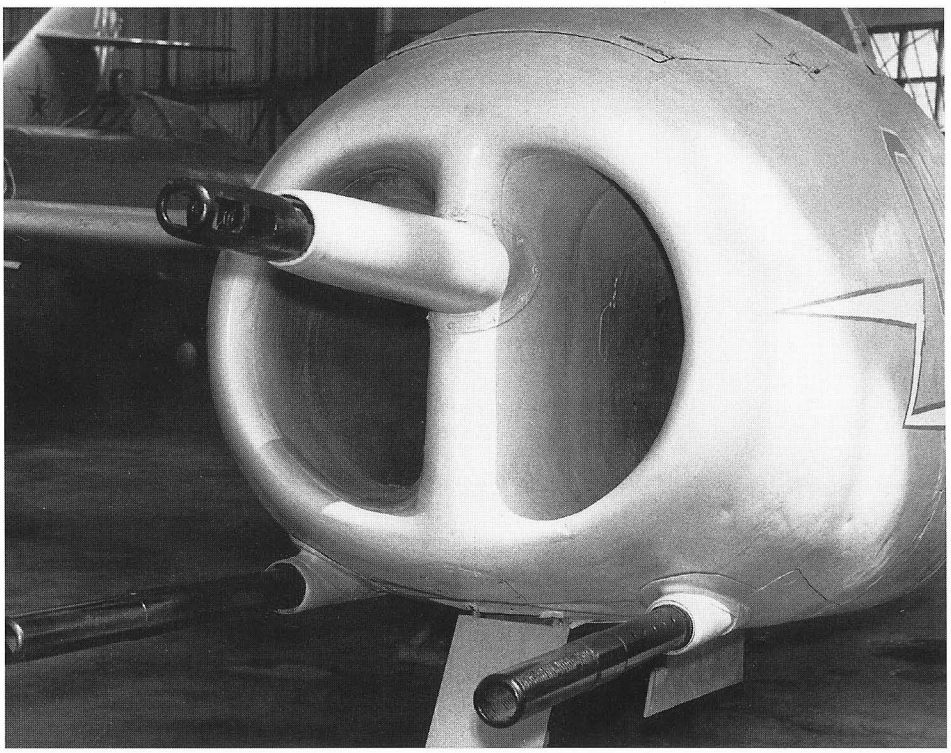
Design work on the dual-control jet commenced at OKB-155 on 15th July 1946. The advanced development project of the two-seat version of the I-300 was approved on 30th October 1946; the aircraft received the OKB designation I-301T and the product code *izdeliye* FT (ie, *izdeliye* F, *treni**ro**vochnoye* – training). As the OKB had to meet stringent deadlines, the first prototype of the UTI MIG-9 (*oo**cheb**no-treni**rov**ochnyy istre**bit**el'* – fighter trainer), alias FT-1, was completed in December 1946; the aircraft was rolled out on 17th January 1947. To save time the ***spar**ka* (a Soviet Air Force slang word for trainers, derived from the words ***spah**rennoye oopravl**en**iye* – dual controls) was converted from one of the initial-production fighters built for the 1947 May Day parade.

In the FT the trainee and the instructor were seated in tandem under a common canopy; the aircraft had dual controls and an SPU-2M intercom (*samo**lyot**noye perego**vor**noye oo**stroy**stvo*). The front and rear cockpits had separate canopies; the front portion hinged to starboard and the rear portion slid aft. Due to provision of the second cockpit the No. 1 fuselage fuel tank had to be deleted and the capacity of the No. 2 tank reduced; the total fuel amount was reduced by exactly one third.

In response to the Air Force's general operational requirement for training aircraft and the stipulations of several Government directives the I-301T was equipped with two ejection seats; however, there were no plans to test them on the first prototype. The ejection seats themselves were designed in-house and assembled at the OKB's experimental production facility (plant No. 155); they were patterned on the German ejection seat installed in the He 162A fighter. The Air Force had not presented any special requirements concerning the ejection seat. The drawings of the Mikoyan seat were sent to plant No. 1 in Kuibyshev in February 1947.

According to the project, the armament of the FT was to comprise a centrally-mounted N-57 cannon and two NS-23 cannons, but only dummy cannons were fitted to the prototype. The two-seater was powered by BMW 003A engines captured in Germany and equipped with a German Bosch LK-2000 generator, while the landing gear wheels and the shimmy damper were taken from the Bell P-63 Kingcobra, the mainwheels measuring 660 x 160 mm (25.74 x 6.24 in) and the nosewheel 480 x 200 mm (18.72 x 7.8 in). For the first time on a Soviet aircraft the cockpit instrumentation included a Mach meter. The rest of the equipment remained unchanged, comprising a second (back-up) GSK-1500 generator, an RSI-6MU receiver, an RSI-6 transmitter, an RPKO-10M DF and a KP-14 oxygen set.





Above and below: Two views of the MiG-9's cannon installation.

The first flight of the FT-1 was performed by Mark L. Gallai. The manufacturer's flight tests (also conducted by Gallai) were completed on 5th April 1947 – almost three months behind schedule because it proved necessary to conduct ground tests of the ejection seats at LII and select the explosive charge for the seat's ejection gun (according to other sources the manufacturer's flight tests report was signed on 29th March). On 11th April the machine was transferred to GK NII VVS for State acceptance trials which started on 21st April and were completed on 2nd June with unsatisfactory results (a total of 37 flights was performed at this stage). The main reason for this negative assessment by the military was the poor view from the rear cockpit during landing (as a result, the aircraft could not be used as a trainer). The concluding part of the State acceptance trials report approved on 31st July 1947 read:

Above: The second prototype of the UTI MiG-9 (I-301T) trainer (FT-2).

The first prototype UTI MIG-9 (FT-1).

'1. The MiG-9UTI (sic) two-seat aircraft submitted for testing cannot be used for training, much less for the familiarisation of flying personnel of service units, due to the lack of the necessary forward view from the rear (instructor's) cockpit during the most critical moments of flight in this aircraft – during take-off and when calculating the landing approach.

2. It is proposed that the Ministry of Aircraft Industry submit once more to GK NII VVS for tests the MiG-9UTI aircraft in which the poor visibility from the rear cockpit and other defects have been rectified.'

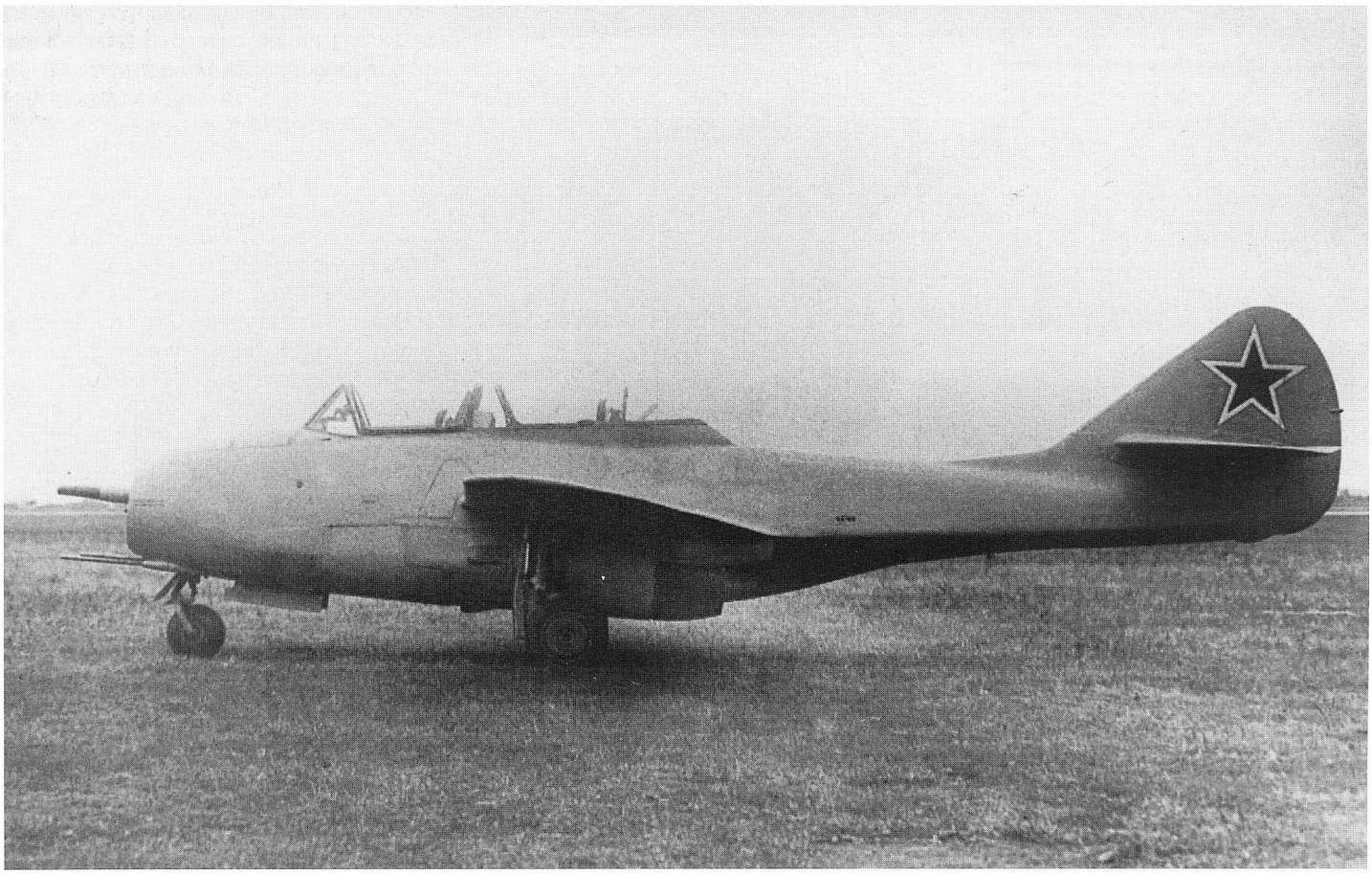
Despite the abortive results of the first *sparka*'s State acceptance trials, the need for series production of a jet trainer was so acute that, without waiting for the results of new tests, the Soviet Council of Ministers in its directive dated 16th May 1947 tasked Plant No.1 in Kuibyshev with starting series manufacture of the UTI MiG-9 (which, nevertheless, never started).

The MiG-9 could go as fast as 900 km/h (486.48 kts), yet the single-seat version of the fighter offered the pilot no means of 'abandoning ship' in an emergency. Even though the first prototype UTI MiG-9 (FT-1) featured ejection seats, they were not tested. Therefore, the prototype construction plan approved by the Council of Ministers in its directive dated 11th March 1947 stipulated that OKB-155 should install functioning ejection seats in the second prototype of the trainer and present it for State acceptance trials in this form. An order issued by the Minister of the Aircraft Industry in the spring of 1947 also stipulated: *'For the purpose of timely preparation of aircraft for the flypast on 18th August of this year [...] Chief Designer and Director of Plant No. 155 Comrade Mikoyan [...] shall complete [...] construction of the second I-301T fighter trainer powered by two [...] RD-20 engines and fitted with an ejection seat (sic) by 15th June; the aircraft is to be flight-tested with a view to preparing it for participation in the flypast...'*

Construction of the second, upgraded prototype of the sparka (designated FT-2) was completed on 15th July 1947, a month later than required. On this aircraft the view from the rear cockpit was considerably improved by replacing of the bulletproof windshield with a simple glass plate of increased size and deleting a partition between the cockpits; the altered shape of the side glazing panels also helped. Besides, the FT-2 had provisions for carrying two 260-litre (57.2 Imp. gal.) drop tanks at the wingtips (to this end 'wet' hardpoints and suitable piping were incorporated in the wings). Stabiliser incidence was increased to 1°30'; the aircraft was equipped with airbrakes and a Fairchild gun camera. The rest of the equipment, with the exception of the German DC generator which was deleted, was identical to that of the FT-1.

Manufacturer's flight tests of the FT-2 were completed on 12th August, whereupon on 26th August the machine was ferried to the GK NII VVS airfield in Shcholkovo for State

Above and below: Two more views of the dual-control UTI MIG-9, showing the seating arrangement and the canopy design.



acceptance trials; these began on 12th August 1947 and were completed on 17th November (the trials report was endorsed on 28th April 1948). They were conducted by project test pilot Maj. V. G. Ivanov, Engineer-Major A. S. Rozanov acting as co-pilot. Other NII VVS pilots also flew the FT-2; these included A. G. Proshakov, V. I. Khomiakov, Yu. A. Antipov, L. M. Koovshinov, D. G. Pikoolenko, Stepan P. Sooproon, Gheorgiy A. Sedov, V. I. Alekseyenko, Terent'yev, Trofimov and Skoopchenko. In all, the second prototype made 47 flights at GK NII VVS, logging a total of 15 hours 32 minutes. The State commission recommended the modified version of the aircraft for series production and Air Force service. In January 1948 the Council of Ministers issued a directive allocating the I-301T (FT) trainer the official designation UTI MiG-9.

The dimensions and performance characteristics of the UTI MiG-9 prototypes are compared in the table on page 31.

As noted above, OKB-155 was required to install ejection seats in the UTI MiG-9 and present the aircraft for State acceptance trials in this configuration. The work was mostly conducted in 1948. The seat developed by the Mikoyan OKB weighed 128.5 kg (283.3 lb). The front and rear ejection seats of the FT-2 were installed at an angle of 22.5° and 18.5° respectively. Ejection was supposed to proceed as follows: of the forward canopy would be jettisoned, followed by the rear canopy, after which the the seats would fire – the rear seat first.

Manufacturer's flight tests of the ejection seat were conducted on the FT-2 at LII in July and August 1948. The seat was fired from the rear cockpit (from which the canopy had been removed), and tester G. A. Kondrashov performed the role of a pilot bailing out. The table at the bottom of page 32 illustrates the results of these tests.

On 29th September 1948 the FT-2 equipped with ejection seats was turned over to GK NII VVS for State acceptance trials. Prior to the flight tests, ten ejections of a dummy were performed on the ground with G forces of 8 to 15, followed by two ejections of a dummy in the air at 596 and 695 km/h (322.16 and 375.67 kts) IAS. Later, military testers Capt. A. V. Bystrov and N. Ya. Gladkov performed three ejections at 517, 612 and 695 km/h (279.45, 330.8 and 375.67 kts) IAS; the flights took place on 7th October, 26th October and 13th November respectively. The aircraft was flown by test pilot Maj. V. G. Ivanov. On the whole the ejection system and the ejection seat received a positive assessment from the military who recommended them for use on production aircraft.

Besides the ejection seat, wing-mounted airbrakes and auxiliary fuel tanks underwent State acceptance trials at GK NII VVS on the UTI MiG-9.

Nevertheless, the *sparka* itself was not put into production. By mid-1948 the single-seat MiG-9 was already outmoded and there was no point in building its two-seat version.

Above: The UTI MiG-9 with drop tanks attached.

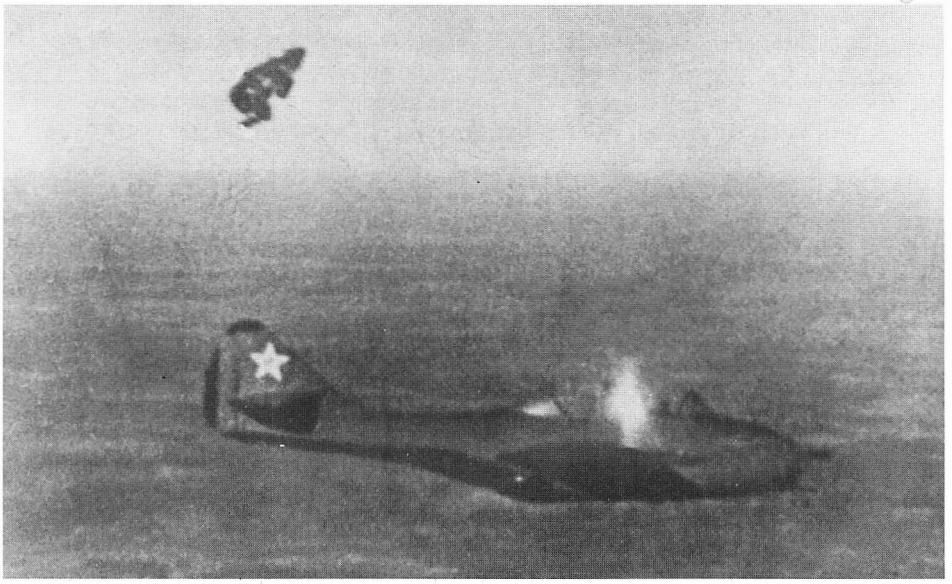
The second prototype (FT-2) with drop tanks seen at GK NII VVS during State acceptance trials.

	UTI MiG-9 1947 project	I-301T-2RD20 (FT-1) Manufacturer's flight tests	I-301T-2RD20 (FT-1) State acceptance trials	UTI MiG9-RD20 (FT-2) State acceptance trials
Powerplant	2 x RD-20	2 x RD-20	2 x RD-20	2 x RD-20
Thrust, kgp (lb st)	2 x 800 (2 x 1,764)	2 x 800 (2 x 1,764)	2 x 800 (2 x 1,764)	2 x 800 (2 x 1,764)
Length (without armament)	-	9.75 m (31 ft 11.85 in.)	9.75 m (31 ft 11.85 in.)	9.75 m (31 ft 11.85 in.)
Height on ground	-	3.225 m (10 ft 6.96 in.)	3.225 m (10 ft 6.96 in.)	3.225 m (10 ft 6.96 in.)
Wing span	-	10.0 m (32 ft 9.7 in.)	10.0 m (32 ft 9.7 in.)	10.0 m (32 ft 9.7 in.)
Stabiliser span	-	3.75 m (12 ft 3.63 in.)	3.75 m (12 ft 3.63 in.)	3.75 m (12 ft 3.63 in.)
Wing area, m^2 (sq ft)	-	18.2 (195.7)	18.2 (195.7)	18.2 (195.7)
Horizontal tail area, m^2 (sq ft)	-	3.76 (40.43)	3.76 (40.43)	3.76 (40.43)
Vertical tail area, m^2 (sq ft)	-	2.4 (25.8)	2.4 (25.8)	2.4 (25.8)
Empty weight, kg (lb)	-	3,584 (7,901)	3,349 (7,383)	3,640 (8,024)
Payload, kg (lb)	-	1,178 (2,597)	1,443 (3,181)	1,245/1,699 (2,745/3,745) [2]
All-up weight, kg (lb)	-	4,762 (10,498)	4,792 (10,564)	4,895/5,339 (10,791/11,770) [2]
Fuel load, kg (lb)	-	840 (1,852)	863 (1,902)	862/1,284 (1,900/2,831) [2]
Wing loading, kg/m^2 (lb/sq ft)	-	262 (53,7)	263 (53.9)	269/293 (55.1/60.0) [2]
Thrust loading, kg/kgp (lb/lb st)	-	2.98	2.99	3.06/3.34 [2]
Maximum speed, km/h (kts):				
at sea level	890 (481.0)	n.a.	n.a.	n.a.
at 5,000 m (16,404 ft)	900 (486.48)	n.a.	n.a.	810/710 (437.83/383.78) [2]
Landing speed, km/h (kts)	165 (89.19)	n.a.	180 (97.3)	180 (97.3)
Climb time to 5,000 m (16,400 ft), minutes	5.0	n.a.	n.a.	5.3/7.3 [2]
360° turn time at 1,000 m (3,280 ft), seconds	27 [1]	n.a.	26-28	26-28
Service ceiling, m (ft)	13,000 (42,651)	n.a.	n.a.	n.a.
Maximum range, km (miles):				
at 1,000 m (3,280 ft)	-	n.a.	235 (146)	n.a./380 (n.a./236) [2]
at 5,000 m (16,404 ft)	-	n.a.	320 (199)	320/510 (199/317) [2]
at 10,000 m (32,808 ft)	500 (311)	n.a.	n.a.	n.a.
Endurance, minutes:				
at 1,000 m	-	40	31	n.a./45 [2]
at 5,000 m	-	n.a.	38	38/55 [2]
Take-off run, m (ft)	895 (2,936) [1]	n.a.	850 (2,788)	835/1,020 (2,739/3,346) [2]
Take-off distance, m (ft)	-	n.a.	1,640 (5,380)	n.a.
Landing run, m (ft)	735 (2,411) [1]	n.a.	1,080 (3,543)	775/920 (2,542/3,018) [2]
Landing distance, m (ft)	-	n.a.	1,755 (5,758)	n.a.
Armament	1 x N-57	1 x N-57 w. 20 rounds	1 x N-37 w. 20 rounds	1 x N-37 w. 20 rounds
	2 x NS-23	2 x NS-23 w. 60 rpg	2 x NS-23 w. 60 rpg	2 x NS-23 w. 60 rpg

Notes:

1. Design performance as calculated by the OKB

2. In 'clean' configuration/with drop tanks; the landing characteristics of the aircraft with drop tanks were determined before experimenting with the braking mode.



A tester is ejected from the rear cockpit of the FT-2 during tests of the ejection seat at LII.

MiG-9 with airbrakes. On 26th March 1947 modification was completed of the fourth MiG-9 of the 'parade' batch (c/n 106004) which was fitted with combined flaps incorporating airbrakes instead of ordinary flaps (the combined flap did not protrude beyond the outline of the wings). Manufacturer's flight tests of this aircraft were completed on 7th July, but State acceptance trials of the airbrakes were not conducted on this machine because a decision was taken to use it for testing the armament. State trials of the airbrakes in the GK NII VVS were conducted, as noted above, on the UTI MiG-9.

MiG-9 with auxiliary fuel tanks. Initially it was envisaged that the third prototype I-300 (F-3) would be equipped with two 260-litre (57.2 Imp gal) drop tanks under the wingtips and would be submitted in this form for State acceptance trials. However, preparation of the aircraft for the 7th November parade prevented this plan from being implemented. As a result, the auxiliary fuel tanks were installed on the first aircraft of the 'parade' batch (c/n 106001), and in this configuration (as already mentioned) it was handed over on 27th December 1946 for manufacturer's flight tests which lasted until 5th April 1947. State acceptance trials at GK NII VVS began on 28th April and were suspended on 8th May owing to the need to replace the RD-20 engines. After this testing of this machine with auxiliary fuel tanks was not resumed (these tests were continued on the UTI MiG-9 and resulted in the recommendation that the drop tanks be used on production fighters).

MiG-9 with a 'butterfly'. It has already been mentioned that the MiG-9's State acceptance trials included special weapon firing tests which were conducted on the fourth machine of the 'parade' batch (no serial, c/n 106004). In accordance with the Council of Ministers directive dated 2nd August 1947 calling for development and additional testing of the armament system on the MiG-9, all three cannons were fitted with special blast suppressor tubes. The blast suppressor of the centrally-mounted N-37 cannon was a tubular vane arranged in the vertical plane (its peculiar shape gave rise to the nickname ***bah**bochka* – butterfly). Theoretically, when the cannons were fired the blast gases would be deflected upwards and downwards, away from the air intake

Apart from aircraft No. 106004, the 'butterfly' device was fitted to one more MiG-9 of the 'parade' batch (c/n 106005) on which afterburning RD-21 engines rated at 1,000 kgp (2,204 lb st) each were installed in the autumn of 1947.

Flight tests of the system were mostly conducted on aircraft No. 106004 between 10th November 1947 and 14th January 1948 (initially at the GK NII VVS airfield in Shcholkovo and then at Saki in the Crimea). It was conducted by test pilot Stepan P. Sooproon, with Berezin and Selivanov as engineers in charge of the aircraft. It was revealed that the 'butterfly' enabled all three cannons to be fired simultaneously only up to the altitude of 10,100 m (33,136 ft); moreover, it disintegrated after a mere 813 rounds were fired. The disintegration of the blast deflector was extremely dangerous for the aircraft (its fragments could be ingested by the engines). Besides, this device impaired the fighter's directional stability, which manifested itself in yawing after three to five shots had been fired (especially at high altitude). On the other hand, when firing the two NS-23Ks together at altitudes up to 10,700 m (35,105 ft) and indicated airspeeds in excess of 320 km/h (173 kts) was accompanied by increasing the engine speed, the blast gases did not affect the engines' operation.

Thus, the desired results were not achieved to the full extent; besides, installation of the 'butterfly' on an aircraft powered by RD-20 engines led to a deterioration of its performance. The design team came to the conclusion that it was necessary to change the placement of the cannons, moving the barrels to aft so that they would not protrude beyond the air intake lip.

I-302 (*izdeliye* FP). To prevent the adverse effect of weapon firing on the functioning of the MiG-9's powerplant the placement of the N-37 cannon was changed on one of the production machines – the weapon was moved to port side of the fuselage. The aircraft was known in the OKB as the I-302 or *izdeliye* FP, the P referring to the relocated cannon (***push**ka*). In 1947 the machine was flown by OKB-155 test pilot V. N. Yooganov. Nevertheless, it proved impossible to eliminate altogether the adverse effect of a three-cannon salvo on the engines' operation.

I-305 (*izdeliye* FL). In November 1947 the experimental production facility of Plant No. 155 completed the airframe of a new version of the MiG-9 which was designated I-305. Its design featured a number of important changes. The two RD-20 engines were replaced by one TR-1A turbojet designed by Arkhip Mikhaïlovich Lyul'ka delivering a thrust of 1,500 kg (3,307 lb); this brought about a redesign of the aft fuselage which housed one engine instead of two. The airframe was reinforced and the armament was rearranged – the cannons mounted around the air intake were placed in one horizontal plane, the N-37 (*izdeliye* 120P) being mounted on the air intake splitter and the two NS-23Ks (*izdeliye* 115P) on the side walls.

Besides, the aircraft was to have a pressurised cockpit equipped with an ejection

Date	Speed, km/h (kts)		G load at the moment of ejection	Altitude, m (ft)
	indicated airspeed	true airspeed		
14th July	450 (243.24)	516 (278.91)	18.0	2,800 (9,186)
17th July	620 (335.13)	705 (381.08)	18.0	2,600 (8,530)
19th August	690 (372.97)	780 (421.62)	18.0	n.a.

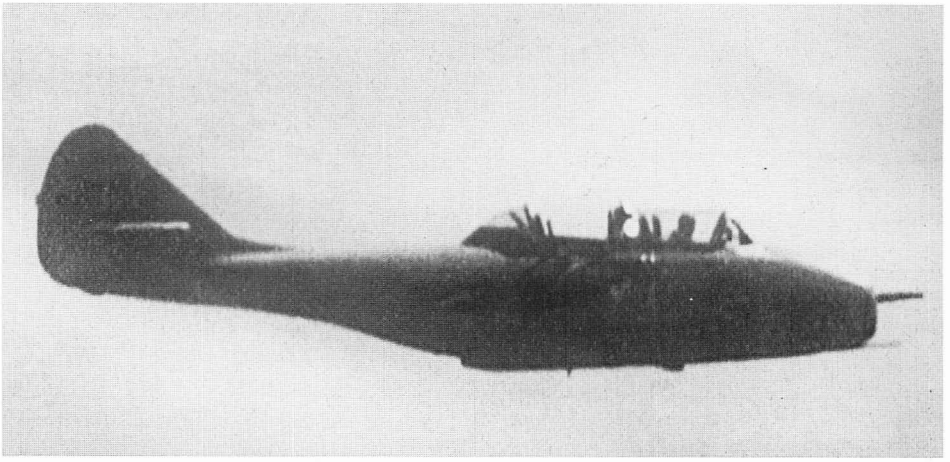
seat; the placement of the cockpit relative to the fuselage would have to be slightly altered because of the relocated cannons. More advanced equipment was also planned for installation (an RSIU-10 radio, a Bariy-1 (Barium) IFF transponder, an NI-46 navigation display (*navigatsi**on**nyy indi**kah**tor*) and a Ton-3 radio direction finder).

The aircraft received the manufacturer's designation *izdeliye* FL, the L referring to the Lyul'ka engine. The importance attached to the work on the FL was due primarily to the fact that it was envisaged eventually to increase the thrust of the first wholly indigenous turbojet to 2,000-2,500 kgp (4,409-5,511 lb). The ammunition supply for the N-37 cannon was increased to 45 rounds, that of the two NS-32Ks remained unchanged at 80 rpg. It proved possible to reduce the fighter's overall weight to 4,500 kg (9,920 lb). However, completion of the machine, its manufacture and its presentation for factory testing were constantly delayed by the unavailability of a normally functioning engine. Besides, the I-310 fighter (aka *izdeliye* S, the future MiG-15 *Fagot-A*) had already entered initial flight tests, and this machine was considered to be more promising. Therefore, work on the FL was discontinued.

I-307 (*izdeliye* FF). In response to the Council of Ministers directives No. 796-318ss dated 9th April 1946 and No. 1249-511ss dated 15th June, as well as to MAP order No.420ss issued on 2nd July 1946, the Mikoyan OKB was engaged in designing a MiG-9 version adapted to take the uprated RD-21 (née BMW 003S) engines delivering 1,000 kgp (2,204 lb st) each. The RD-21 differed from the RD-20 in having an afterburner developed by OKB-155 under the direction of Gleb Yevgen'yevich Lozino-Lozinskiy which made it possible to briefly increase the engine's thrust to 1,000-1,050 kgp (2,204-2,315 lb). Powered by these engines, the MiG-9 was to attain a maximum speed of 920 km/h (497.29 kts) at sea level and 950 km/h (513.51 kts) at 5,000 m (16,404 ft). Climb to the service ceiling of 13,000 m (42,651 ft) was to be effected within 12 minutes, and a range of 800 km (497 miles) was to be attained in the optimum cruise mode. According to the specification, the aircraft was to be armed with one 45-mm cannon and two 23-mm cannons. The first of two prototypes was to enter flight test in April 1947. By the end of 1946 the specification for the RD-21-powered fighter underwent some changes (see table below).

OKB-155 completed the development work with barely one month's delay. A MiG-9 powered by two afterburning BMW 003S engines (the Soviet reverse-engineered version, the RD-20F (*for**see**rovannyy*), later redesignated RD-21, had not yet been tested at the time) was cleared for manufacturer's flight tests on 19th May 1947; same month it was flown by OKB test pilot V. N. Yooganov. The aircraft received the OKB designation I-307 and the product code *izdeliye* FF (ie, *izdeliye* F *s for**see**rovannymi **dvig**atelyami*, with uprated engines). Some documents quote the designation **I-307-2BMW 003S**. In addition to the new powerplant, the fighter was provided with 12-mm armour plates fore and aft of the cockpit and a bulletproof windscreen 44 mm (1.73 in.) thick. The weight of the cockpit armour totalled 60 kg (132 lb). The fighter's armament remained identical to that of the production MiG-9, consisting of one N-37 (120P) cannon with 45 rounds and two NS-23K (115P) cannons with 80 rpg. The avionics and equipment fit was likewise unchanged, comprising a GSK-1500 generator, a 12-A-10 DC battery, an RSI-6 radio, a Fairchild gun camera and a KP-14 breathing apparatus.

The manufacturer's flight tests conducted by OKB-155 test pilot V. N. Yooganov were completed on 21st June (the test report was endorsed on 9th July). The fighter's top speed at 3,000 m (9,842 ft) rose to 950 km/h (513.51 kts) and the time required to reach 5,000 m (16,404 ft) was reduced to 3.9 min. Due to the necessity of replacing the engines the FF was not submitted for State acceptance trials until 40 days later, on 2nd August. However, the trials lasted only three weeks – the prototype crashed on 19th August.



Above: Another air-to-air of the FT-2. Note that the rear canopy has been removed.

A head-on view of a UTI MiG-9 with the airbrakes deployed.

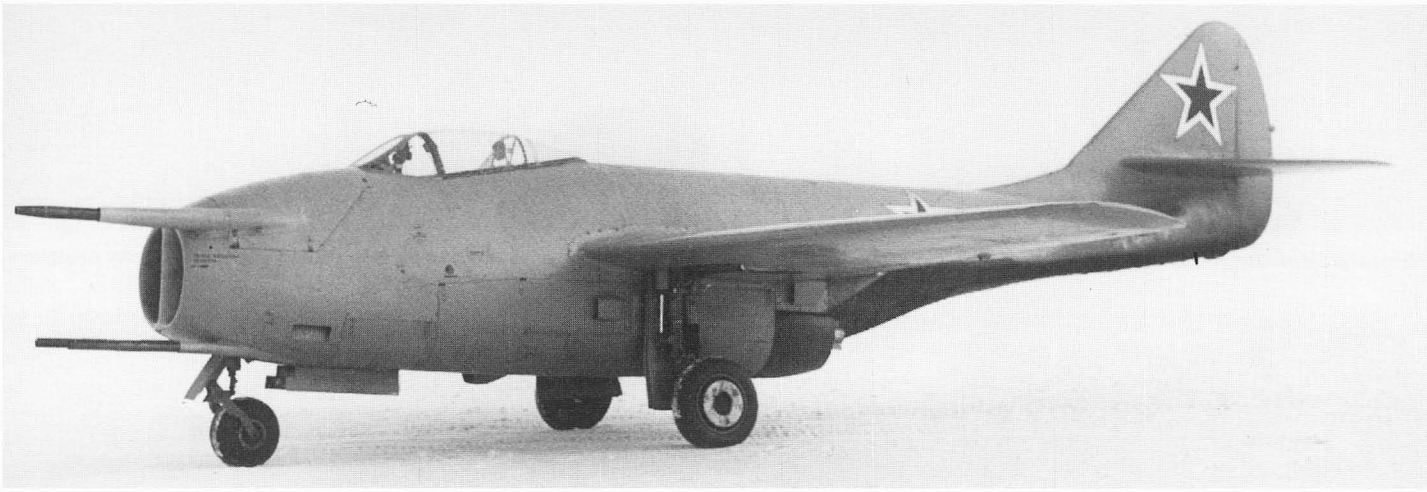
September 1947 saw the completion of the second MiG-9 (*izdeliye* FF) prototype, powered this time by RD-21 engines which had been assembled by plant No. 16 in Kazan' from Soviet-designed components. The aircraft was converted from the fifth MiG-9 of the initial-production batch (c/n 106005). In addition to the more powerful engines, the fighter featured new brake wheels and enhanced cockpit armour patterned on that of the first I-307. Besides, a 'butterfly' type blast deflector was fitted to the centrally-mounted N-37 cannon.

Designated **MiG9-2RD21**, the second prototype took to the air in December 1947 at the hands of OKB-155 test pilot I. T. Ivaschchenko; the report on the first stage of the fighter's flight tests was signed on 31st January 1948. The aircraft showed a top speed of 947 km/h (511.89 kts) at 3,000 m (9,842 ft) and 928 km/h (501.62 kts) at 5,200 m (17,060 ft), ie, Mach 0.82 and 0.816 respectively.

According to Mikoyan OKB records, MiG-9 fighters powered by RD-21 engines

Above and below: This MiG-9 was equipped with an experimental blast deflector (dubbed *bahbochka*, butterfly) on the barrel of the N-37 cannon in an effort to prevent engine flameout when the cannons were fired. The installation could not cure the problem and was abandoned.

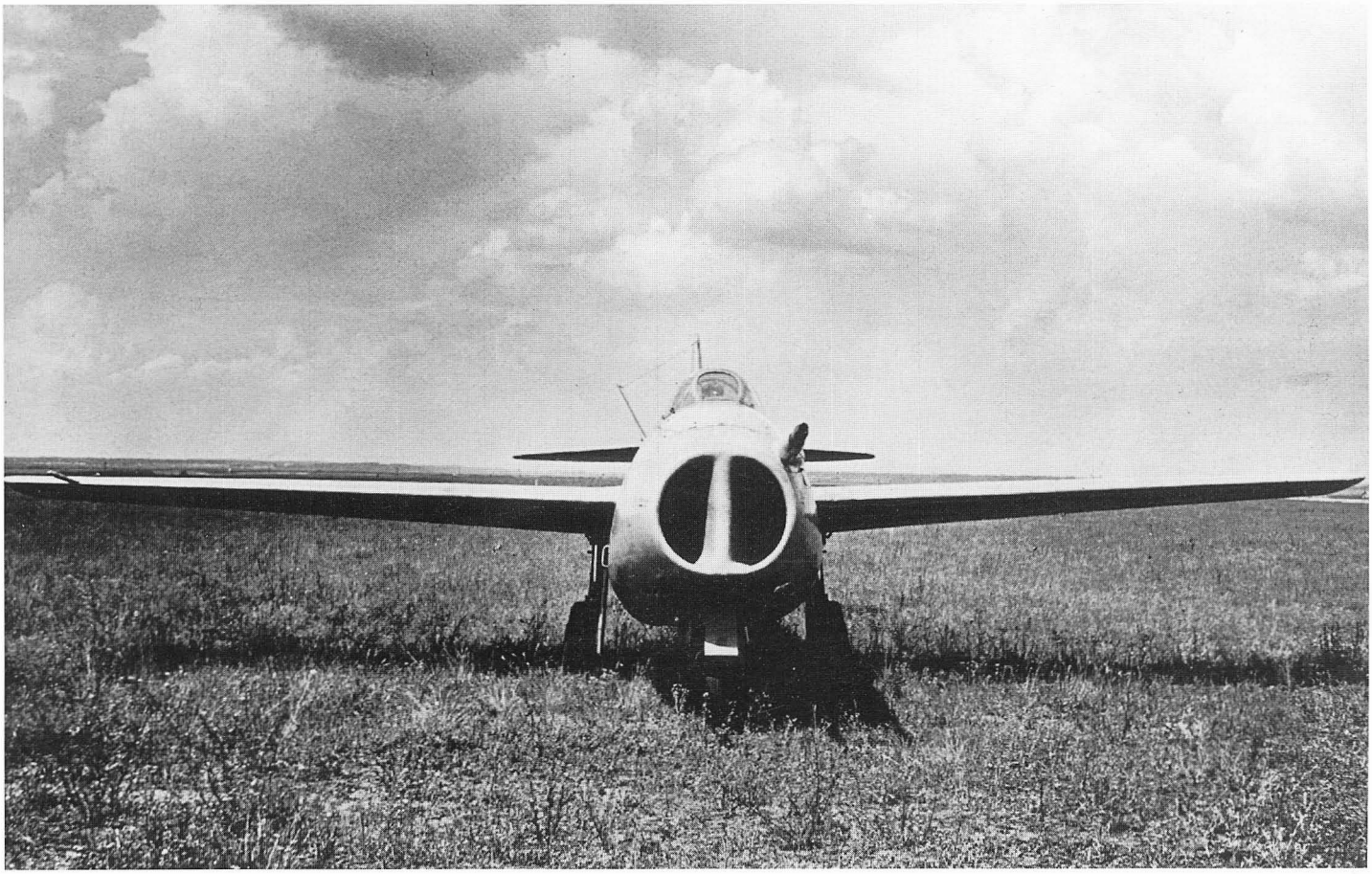
Above: In another approach to the problem, this MiG-9 was equipped with a muzzle brake on the centre cannon.

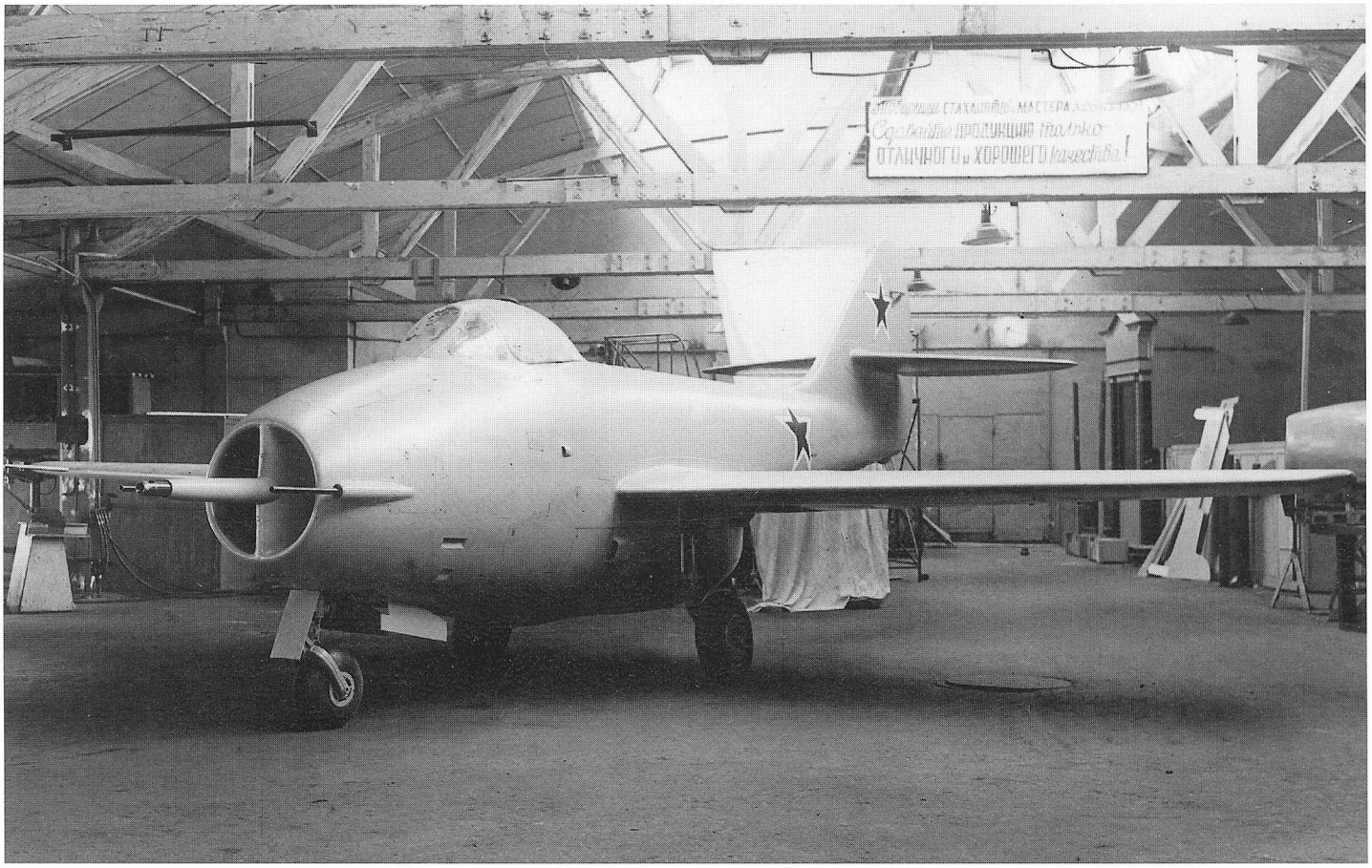


Above and below: Two views of the I-302 (FP) prototype with the offset N-37 cannon. The unusual weapons arrangement was yet another attempt to cure the blast gas ingestion problem.

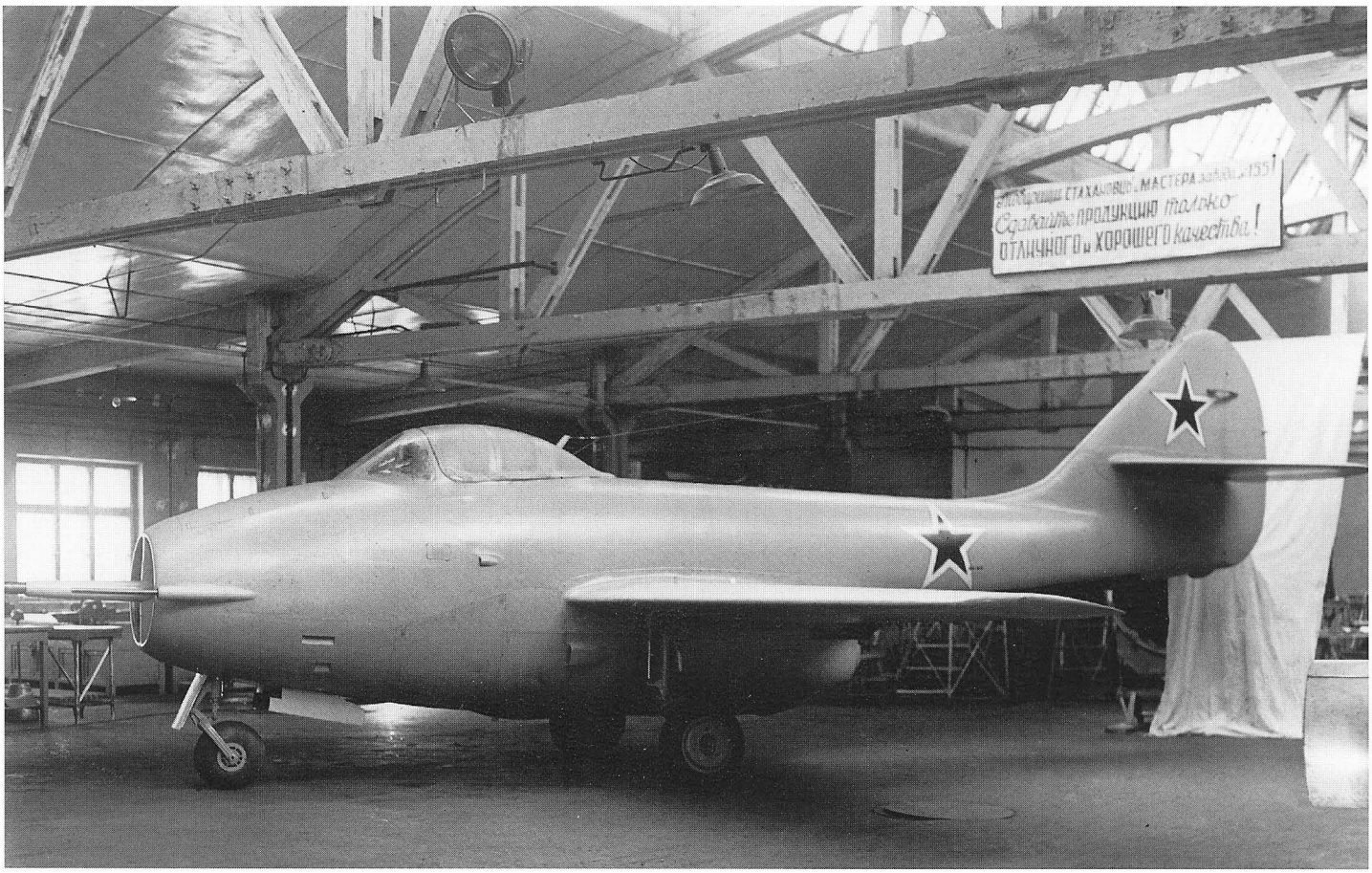
Above and below: Three-quarters front view and side view of the I-302.

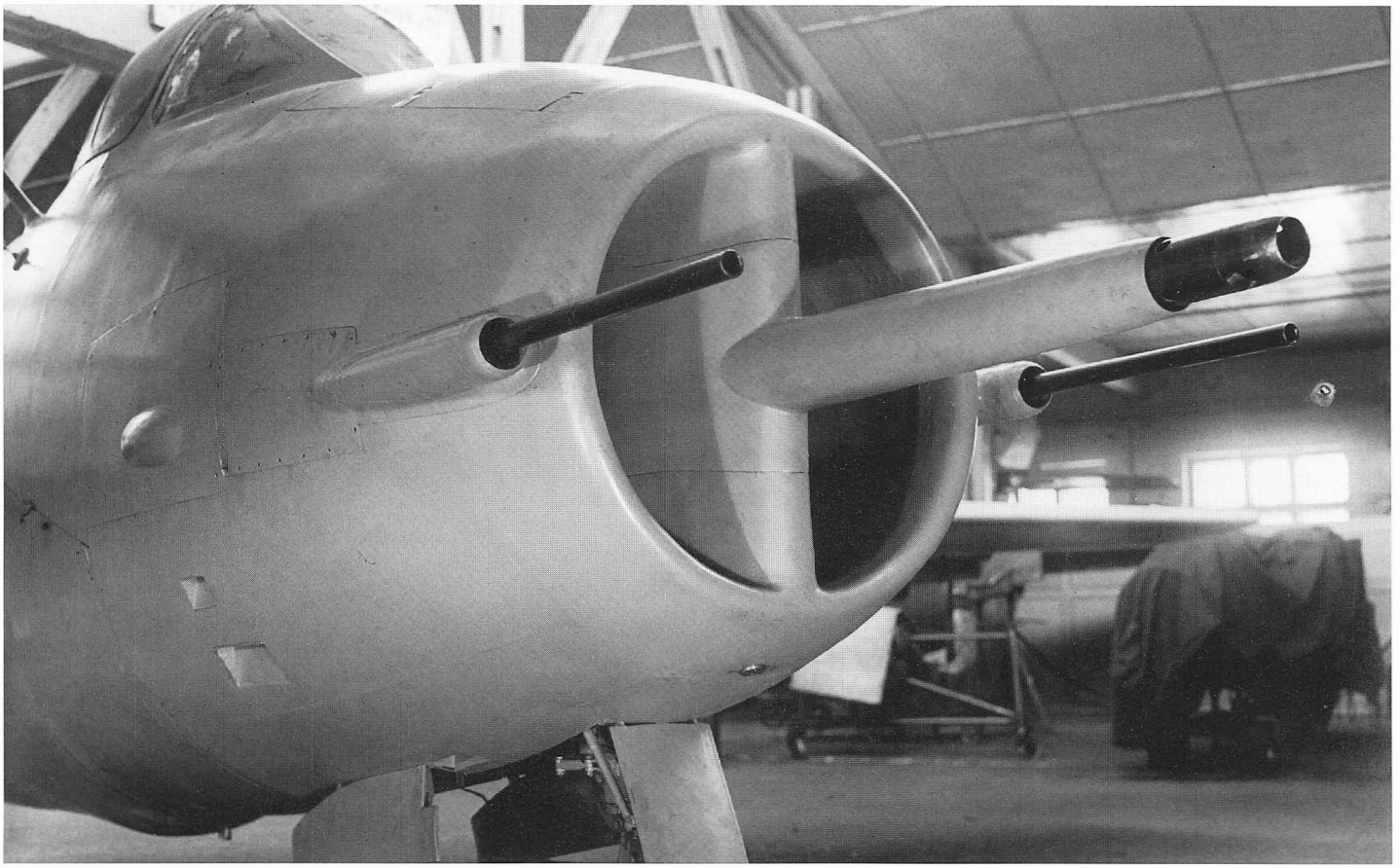
Above and below: Two more views of the same aircraft.



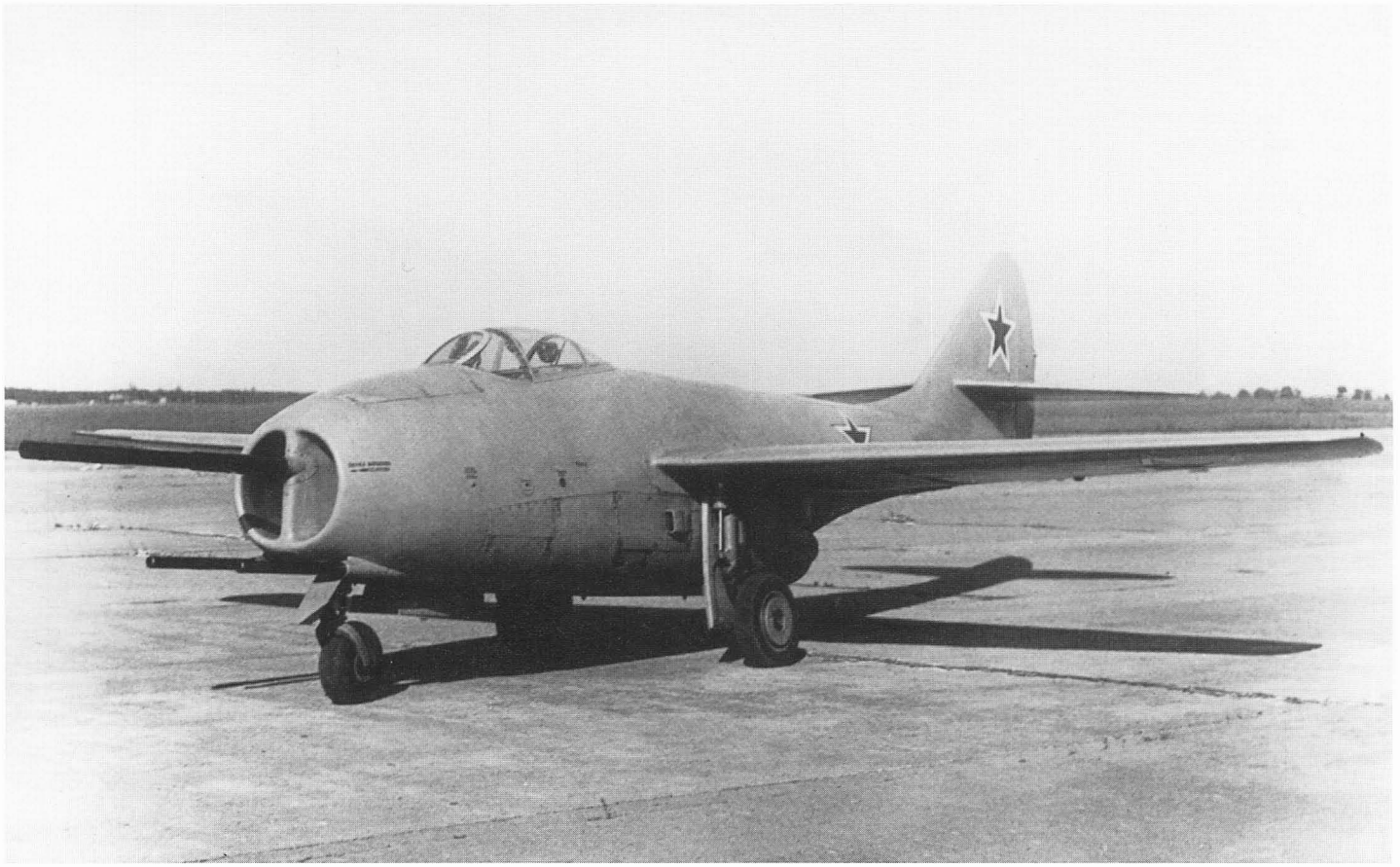


Above and below: The I-305 (FL) prototype in the assembly shop of MMZ No. 155. The single-engined derivative of the MiG-9 was never flown.





Above: Close-up of the I-305's weapons arrangement with all three cannons located in the horizontal plane.



This MiG-9 had a centre cannon fitted with a lengthened barrel in yet another attempt to cure the engines' tendency to flame out when the cannons were fired.

MiG-9 fighters with afterburning engines

	1947 specification	I-307-2BMW 003S (FF) Manufacturer's flight tests	MiG9-2RD-21 (c/n 106005 modified) Manufacturer's flight tests
Powerplant	2 x RD-21	2 x BMW 003S	2 x RD-21
Thrust, kgp (lb st)	2 x 1,000 (2,205)	2 x 1,050 (2,315)	2 x 1,000 (2,205)
Length (without armament)	-	9.75 (32)	9.75 (32)
Height on ground	-	3.225 (10.6)	3.225 (10.6)
Wing span	-	10.0 (32.8)	10.0 (32.8)
Stabiliser span	-	3.75 (12.3)	3.75 (12.3)
Wing area, m² (sq ft)	-	18.2 (195.8)	18.2 (195.8)
Horizontal tail area, m² (sq ft)	-	3.50 (37.65)	3.50 (37.65)
Vertical tail area, m² (sq ft)	-	2.40 (25.8)	2.40 (25.8)
Empty weight, kg (lb)	-	n.a.	n.a.
Payload, kg (lb)	-	n.a.	n.a.
All-up weight, kg (lb)	-	5,020 (11,069)	5,040 (11,113)
Fuel load, kg (lb)	-	1,300 (2,866)	n.a.
Wing loading, kg/m² (lb/sq ft)	-	276 (56.57)	277 (56.77)
Thrust loading, kg/kgp (lb/lb st)	-	4.78 (4.78)	5.04 (5.04)
Top speed, km/h (kts):			
at sea level	900 (486.48)	n.a.	n.a.
at 3,000 m (9,842 ft)	-	950 (513.51)	n.a.
at 5,000 m (16,404 ft)	930 (502.7)	n.a.	947 (511.89)
at 5,200 m (17,060 ft)		n.a.	928 (501.62)
Time to height, minutes:			
to 5,000 m (16,404 ft)	4.0	3.9	2.95
to 10,000 m (32,808 ft)	-	n.a.	7.9
Rate of climb, m/sec (ft/min):			
at sea level	-	24.0 (4,723)	n.a.
at 5,000 m	-	17.8 (3,503)	n.a.
Service ceiling, m (ft)	13,000 (42,651)	n.a.	n.a.
Maximum range at 10,000 m, km (miles):			
in 'clean' configuration	800 (497)	n.a.	n.a.
with drop tanks	900 (559)	n.a.	n.a.
Take-off run, m (ft)	800 (2,624)	850 (2,788)	700 (2,296)
Landing run, m (ft)	740 (2,427)	n.a.	740 (2,427)

and fitted with a standard armament fit were series-produced for some time.

The table on this page illustrates the dimensions and performance of MiG-9 fighters with afterburning engines as recorded during manufacturer's flight tests.

MiG-9M (I-308, *izdeliye* FR). In June 1947 the prototype of a modified version designated MiG-9M (modifitseerovannyy) was built at Plant No. 155. Its in-house designation was I-308, the product code being *izdeliye* FR, but in documents it was usually referred to as the 'modified MiG9-2RD21 aircraft with a pressurised cockpit, airbrakes and revised armament arrangement'. The FR differed from the production MiG-9 (*izdeliye* FS) in the following respects. To improve performance the RD-20 engines were replaced by afterburning RD-21s rated at 1,000 kgp (2,204 lb). To stop the cannons from affecting the engines' operation when they were fired all together, the armament was rearranged; the cannons were moved well aft and buried completely in the forward fuselage so that the barrels did not protrude beyond the air intake lip (the N-37 cannon was placed on starboard side of the fuselage, while both NS-23s were installed on port side).

The relocation of the armament required the pressurised cockpit to be moved slightly forward, which gave a bonus in the form of an improved view over the nose. The cockpit was provided with an ejection seat. The airbrakes were mounted on the flaps so that they did not protrude beyond the wings' outline.

The fuel system layout was altered; the number of tanks was reduced from six to five but their total capacity remained unchanged. Also, one of the tanks holding 100 litres (22 Imp gal) was designated as a trim tank for maintaining the CG position as the fuel burned off.

The 12-A-10 DC battery was replaced by a higher-capacity 12-A-30 battery. Apart from this, the fighter's equipment remained unchanged, comprising an RSI-6 transmitter, an RSI-6M receiver, an RPKO-10M DF, an S-13 gun camera, a GSK-1500 DC generator and a KP-14 breathing apparatus with a 4-litre (0.88 Imp gal) oxygen bottle. As usual, the pilot was protected by an armoured seat back and headrest; besides, the windshield incorporated a frame for a bulletproof windscreen 85 mm (3.34 in.) thick.

The modified MiG-9 with RD-21 engines and rearranged armament made its first flight in July 1947 at the hands of OKB test pilot I. T. Ivaschchenko (some sources claim it was V. N. Yooganov who took the machine into the air). The manufacturer's flight tests were completed in the spring of 1948 (the test report was approved on 26th April). The MiG-9M was the first of the jet MiGs to exceed Mach 0.8 – during initial flight tests a maximum speed of 942 km/h (585 mph) was attained at 3,000 m (9.840 ft), which corresponds to Mach 0.81. Then the fighter was handed over for State trials – and received a thumbs-down. The concluding part of the GK NII VVS report approved on 3rd September 1947 said:

'1. The modified MiG-9 'FR' aircraft has passed State acceptance trials with unsatisfactory results, the reasons being:

a) the engines flame out after a salvo firing of the weapons at altitudes in excess of 8,000 m (26,246 ft) if the throttles are advanced concurrently or the engines run at low rpm;

b) the mounts for the N-37 and NS-23 cannons have not been fully developed;

c) the workmanship standard of the pressurised cockpit is low.

2. Further development of this aircraft is considered inexpedient.'

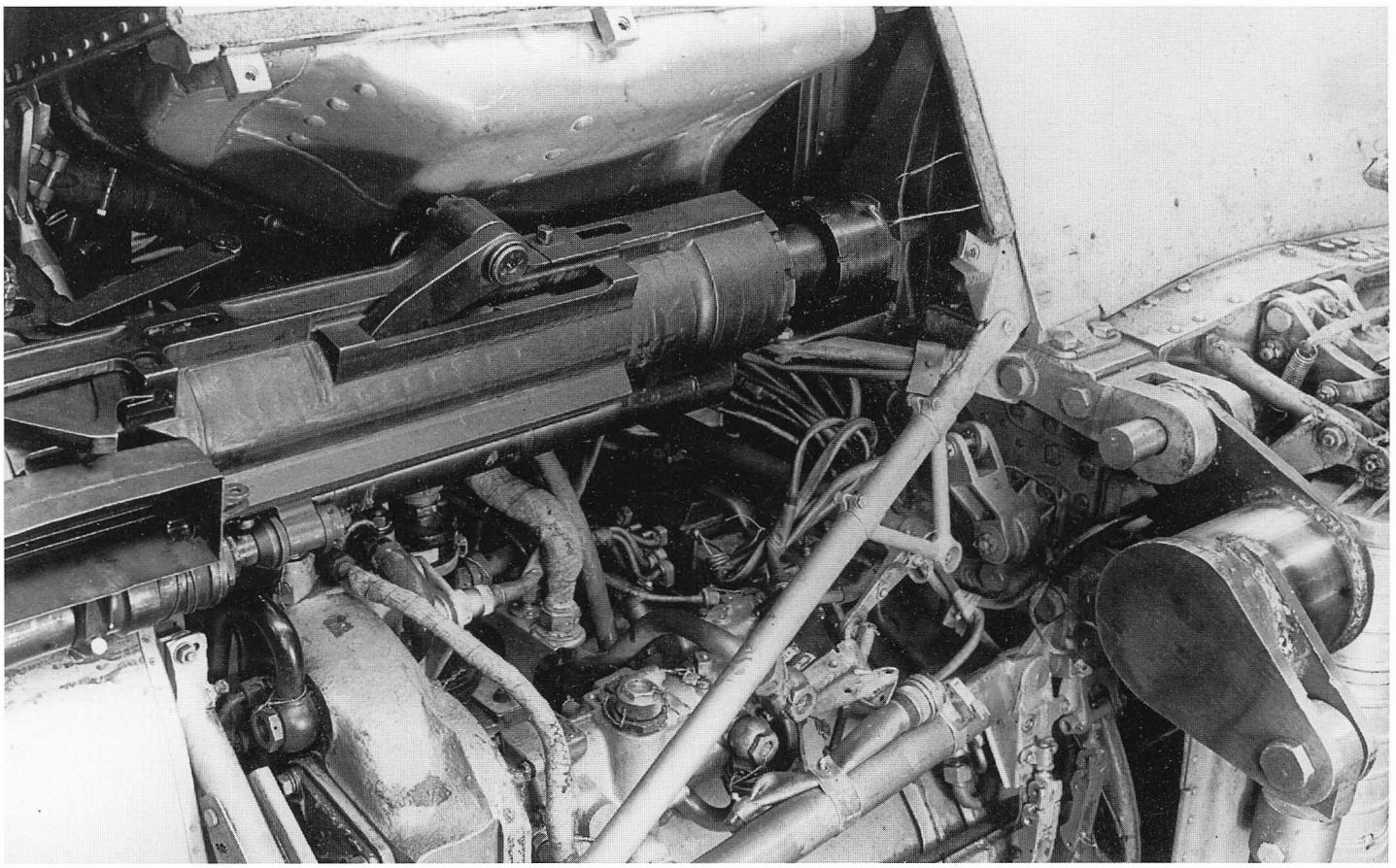
By then the testing of the I-310 prototype (the future MiG-15) was already in full swing, and further work on the FR was pointless.

The specifications of the MiG9-2RD21 (FR) are detailed in the table on page 44.

I-320 (*izdeliye* FN). The designation I-320 was used by the Mikoyan OKB for the first time when it embarked on the development and construction of a MiG-9 version powered by one Rolls-Royce Nene I centrifugal-flow turbojet rated at 2,230 kgp (4,916 lb st). The was also known as *izdeliye* FN (ie, *izdeliye* F with a Nene engine). Once again, the armament was rearranged in yet another attempt to stop the blast gases from affecting the powerplant. The N-37 cannon was buried in the forward fuselage underside and the NS-23s were mounted laterally; as on the FR, the cannon barrels did not protrude beyond the air intake lip. Besides, the airframe strength was increased.

Prototype construction began at the end of 1947, but it was never completed because the project was obviously a dead duck. The

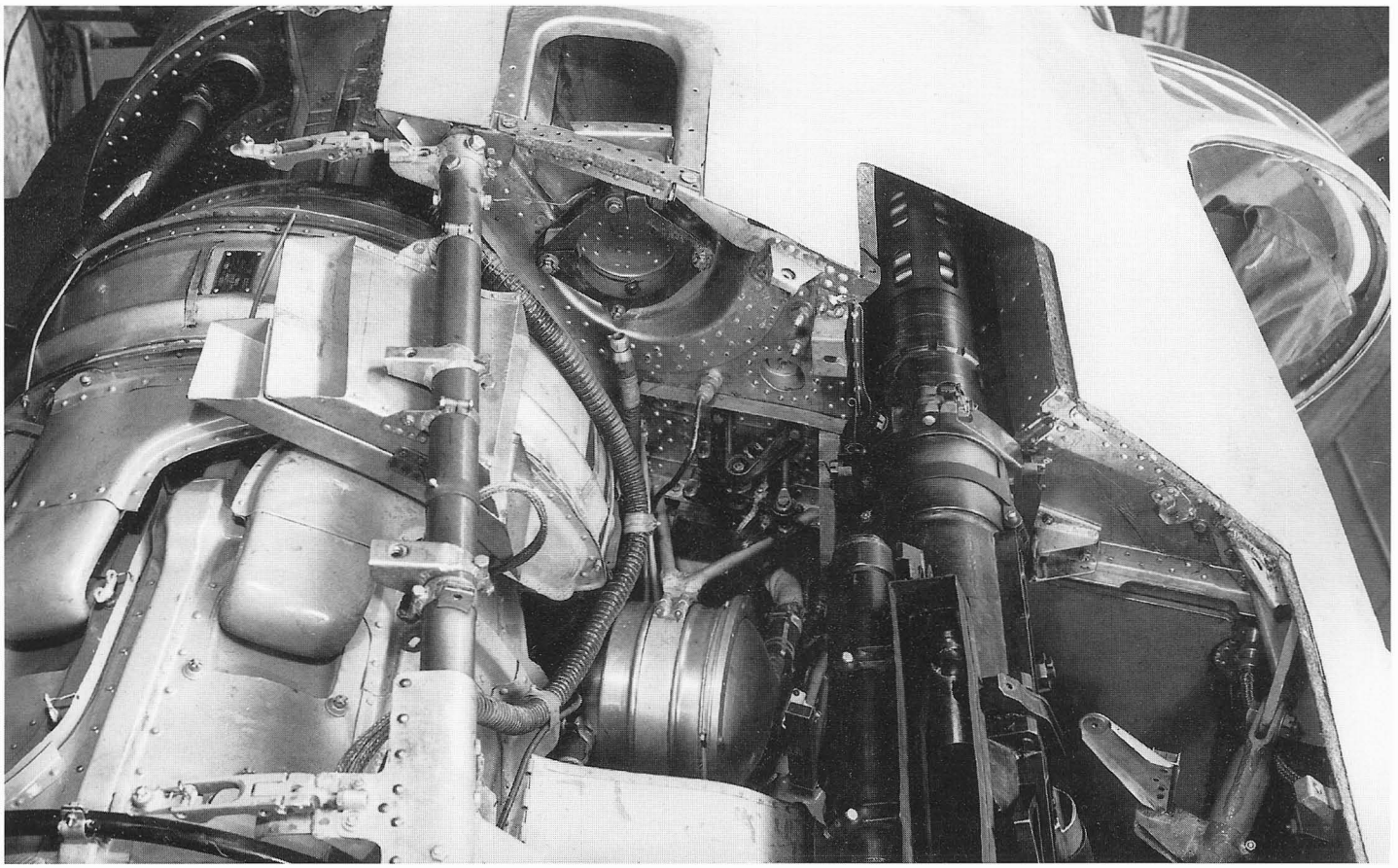
Above: The MiG-9M (FR) prototype. This view shows clearly the redesigned forward fuselage with the relocated armament and forward-positioned cockpit.



Close-up of the MiG-9M's portside cannon bay. The port engine can be seen at the bottom of the picture.

Above and below: Two more views of the MiG-9M prototype during trials.

Above: Three-quarters rear view of the MiG-9M (FR) with the airbrakes deployed.



The MiG-9M's forward fuselage with all cowlings and access panels removed.

MiG-9M (MiG9-2RD21, *izdeliye* FR) specifications

	Manufacturer's flight tests	State acceptance trials
Powerplant	2 x RD-21	2 x RD-21
Thrust, kgp (lb st)	2 x 1,000 (2,204)	2 x 1,000 (2,204)
Length (without armament)	9.75 m (31 ft 11.85 in.)	9.75 m (31 ft 11.85 in.)
Height on ground	3.225 m (10 ft 6.96 in.)	3.225 m (10 ft 6.96 in.)
Wing span	10.0 m (32 ft 9.7 in.)	10.0 m (32 ft 9.7 in.)
Stabiliser span	3.75 m (12 ft 3.63 in.)	3.75 m (12 ft 3.63 in.)
Wing area, m2 (sq ft)	18.2 (195.7)	18.2 (195.7)
Horizontal tail area, m^2 (sq ft)	3.76 (40.43)	3.76 (40.43)
Vertical tail area, m^2 (sq ft)	2.4 (25.8)	2.4 (25.8)
Empty weight, kg (lb)	3,595 (7,925)	3,430 (7,561)
Payload, kg (lb)	1,531 (3,375)	1,740 (3,836)
All-up weight, kg (lb)	5,126 (11,301)	5,170 (11,397)
Fuel load, kg (lb)	1,297 (2,859)	1,308 (2,883)
Wing loading, kg/m^2 (lb/sq ft)	282 (57.8)	284 (58.2)
Thrust loading, kg/kgp (lb/lb st)	2.57	2.58
Maximum speed, km/h (kts):		
at sea level	n.a.	872 (471.35)
at 3,000 m (9,842 ft)	942 (509.19)	n.a.
at 5,000 m (16,404 ft)	925 (500.0)	n.a.
at 6,000 m (19,685 ft)	n.a.	917 (495.67)
at 10,000 m (32,808 ft)	n.a.	873 (471.89)
Landing speed, km/h (kts)	n.a.	173 (93.5)
Time to height, minutes:		
to 5,000 m	3.1	3.5
to 10,000 m	8.0	10.4
Rate of climb, m/sec (ft/min):		
at sea level	n.a.	28.0 (5,510.4)
at 5,000 m	n.a.	19.2 (3,778.56)
at 10,000 m	n.a.	8.0 (1,574.4)
Service ceiling, m (ft)	n.a.	14,000 (45,931)*
360x turn time at 5,000 m, sec	n.a.	30.5
Maximum range, km (miles)	820 (509)	n.a.
Take-off run, m (ft)	700 (2,296)	640 (2,099)
Take-off distance, m (ft)	n.a.	1,380 (4,527)
Landing run, m (ft)	740 (2,427)	920 (3,018)
Landing distance, m (ft)	n.a.	1,600 (5,249)
Armament	1 x N-37	1 x N-37
	w. 35 rounds	w. 35 rounds
	2 x NS-23	2 x NS-23
	w. 75 rpg	w. 75 rpg

** Note: this is an estimated figure; the highest altitude actually attained during State acceptance trials was 12,300 m (40,354 ft).*

An artist's impression of the I-320 (FN).

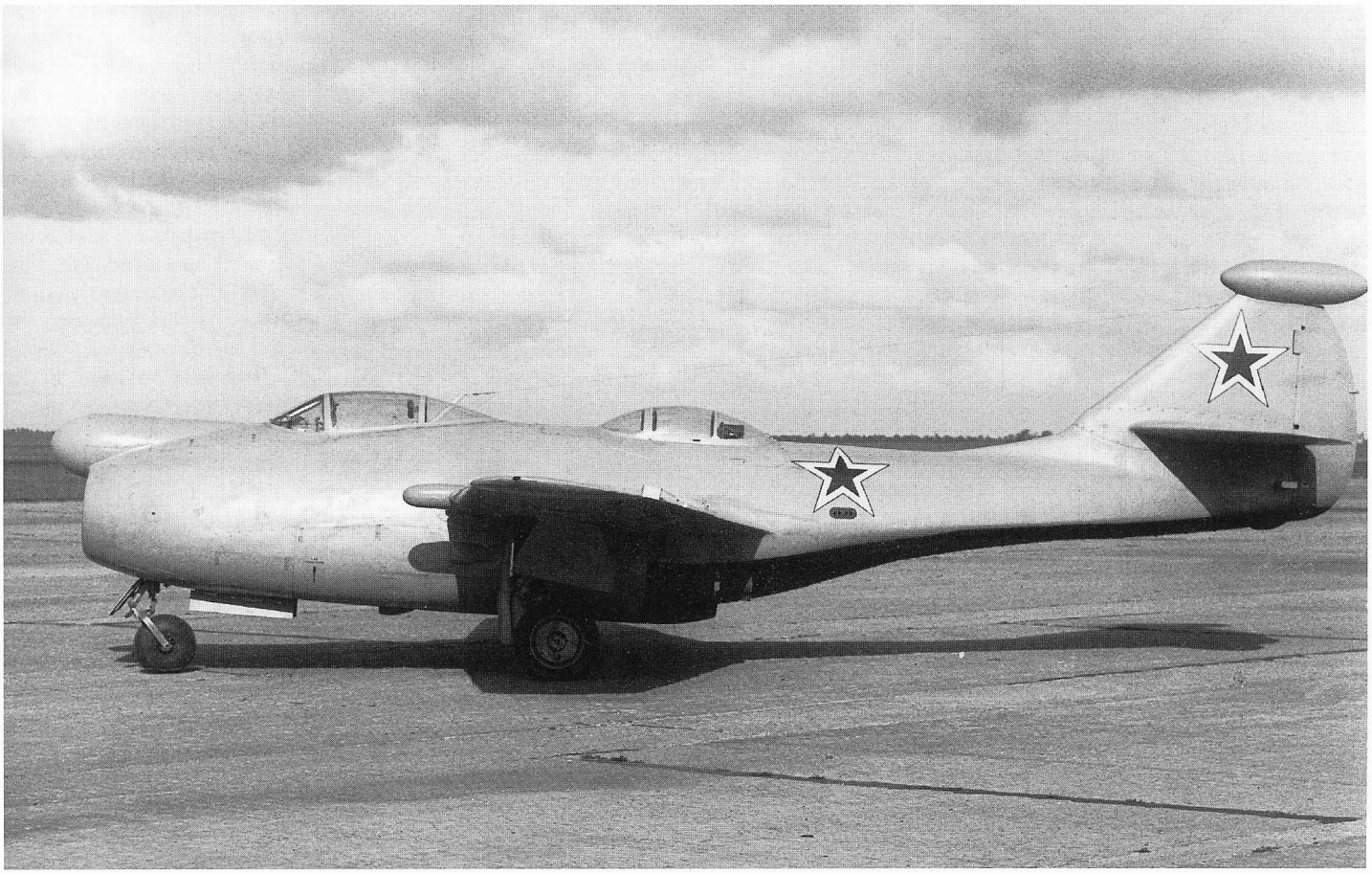
swept-wing I-310 powered by the same RR Nene I engine had higher design performance; therefore, the unfinished *izdeliye* FN was scrapped. The designation I-320 was subsequently reused for a 'clean sheet of paper' design – the *izdeliye* R two-seat twin-engined all-weather interceptor of 1949.

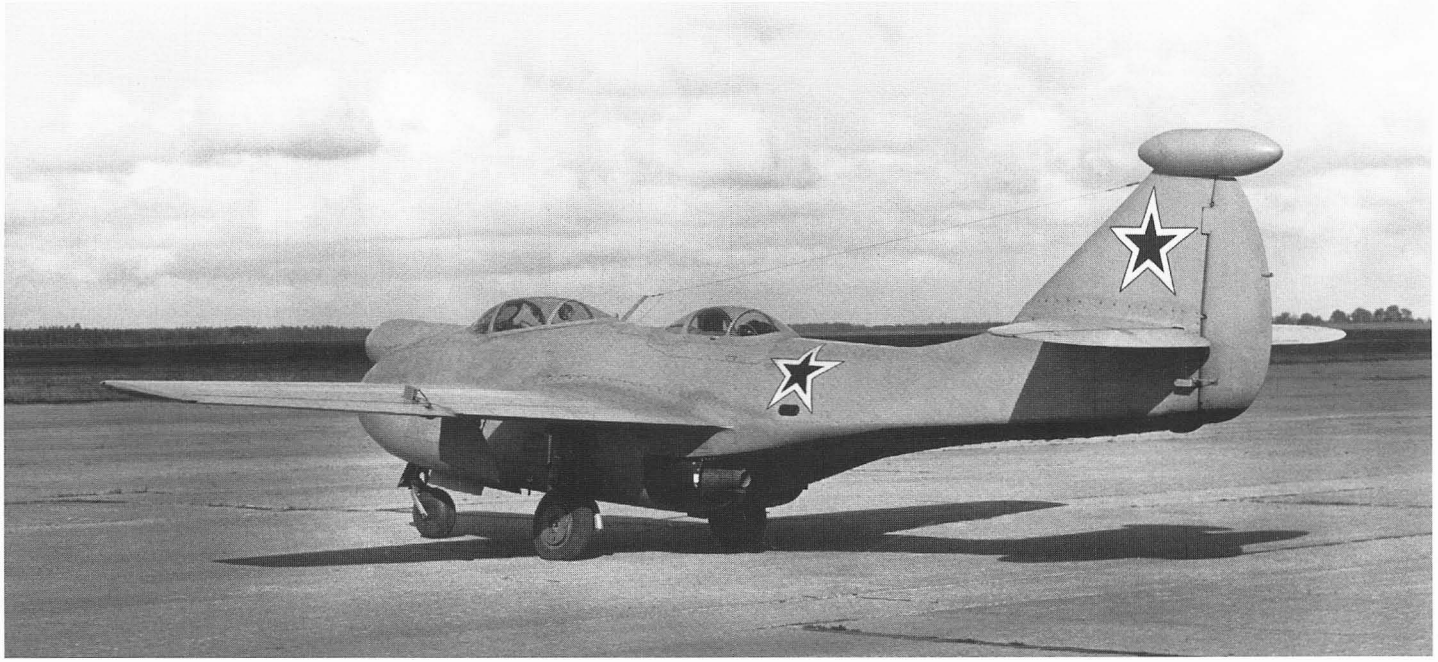
MiG-9L (*izdeliye* FK). A single production MiG-9 was converted into an avionics testbed for the purpose of verifying the guidance system of the KS-1 anti-shipping cruise missile (NATO code name AS-1 *Kennel*). Looking rather like a scaled-down MiG-15, this stand-off weapon had been developed by a branch of the Mikoyan OKB under the *Kometa* (Comet) programme. Hence the heavily modified *Fargo*, which bore the designation MiG-9L (for *[letayuschchaya] laboratoriya* – testbed or research aircraft), also had the product code *izdeliye* FK, ie, aircraft F with the Kometa system.

Conversion of the aircraft was completed on 14th May 1949. It had a crew of two – the pilot and the guidance system operator; the latter sat in a separate unpressurised cockpit with a bubble canopy immediately ahead of the wing trailing edge where one of the fuel tanks used to be. Like the KS cruise missile, the FK was equipped with two radars. A K-1M target illumination radar (used during the terminal guidance phase) was installed in a large bullet-shaped radome above the air intake, protruding perceptibly above the nose contour. Signals reflected from the target were received by two antennas accommodated in small cylindrical pods mounted on the wing leading approximately at mid-span. A second, aft-looking transceiver radar was installed in a rather large cigar-shaped fairing on top of the fin; it was intended for testing the systems providing mid-course guidance from the missile's carrier aircraft, as well as the guidance system of the missile itself. The armament was deleted, of course.

Development of the Kometa system's avionics on the MiG-9L (FK) testbed began in 1949 and went on for four years. Other test aircraft involved in the programme included the MiG-17K (MiG-17SDK) cruise missile imitator, which had the same guidance system, and the *izdeliye* K imitator aircraft which was a manned version of the actual KS-1 with a retractable bicycle landing gear and a cockpit instead of the explosive charge. In the course of the Kennel's trials, prototype missiles were launched from a Tupolev Tu-4 bomber was used as a carrier aircraft. Eventually the missile passed its State acceptance trials successfully in 1952-53 and was included into the Soviet Navy inventory, the Tu-16KS *Badger-B* acting as the carrier aircraft.

Above and below: The bizarre-looking MiG-9L (FK) served as a testbed for the KS-1 missile's guidance system. The many radomes and the second cockpit for the guidance system operator are well visible.





A three-quarters rear view of the MiG-9L avionics testbed.

Specifications of some MiG-9 versions

Service designation	**none**	**MiG-9**	**UTI MiG-9** [1]	**none**	**none**	**MiG-9M**
OKB designation	**I-300**	**I-301**	**I-301T**	**I-305** [2]	**I-307**	**I-308**
Product code	**Izdeliye F**	**Izdeliye FS**	**Izdeliye FT**	**Izdeliye FL**	**Izdeliye FF**	**Izdeliye FR**
Powerplant	2 x RD-20	2 x RD-20	2 x RD-20	1 x TR-1	2 x RD-20F	2 x RD-20
Thrust, kgp (lb st)	2 x 900	2 x 900	2 x 900	1,500	2 x 1,050	2 x 1,000
	(2 x 1,984)	(2 x 1,984)	(2 x 1,984)	(3,307)	(2 x 2,315)	(2 x 2,204)
Length (without armament)	9.75 m	9.75 m	9.75 m	n.a.	9.75 m	n.a.
	(31 ft 11.85 in.)	(31 ft 11.85 in.) [3]	(31 ft 11.85 in.) [3]		(31 ft 11.85 in.) [3]	
Height on ground	3.225 m	3.225 m	3.225 m	n.a.	3.225 m	n.a.
	(10 ft 6.96 in.)	(10 ft 6.96 in.)	(10 ft 6.96 in.)		(10 ft 6.96 in.)	
Wing span	10.0 m	10.0 m	10.0 m	10.0 m	10.0 m	10.0 m
	(32 ft 9.7 in.)	(32 ft 9.7 in.)	(32 ft 9.7 in.)	(32 ft 9.7 in.)	(32 ft 9.7 in.)	(32 ft 9.7 in.)
Wing area, m^2 (sq ft)	18.2 (195.7)	18.2 (195.7)	18.2 (195.7)	18.2 (195.7)	18.2 (195.7)	18.2 (195.7)
All-up weight, kg (lb):						
normal	4,998 (11,018)	4,998 (10,999)	4,762 (10,498)	4,600 (10,141)	n.a.	n.a.
maximum	n.a.	n.a.	4,792 (10,564)	n.a.	5,040 (11,111)	5,140 (11,331)
Fuel load, kg (lb)	1,320 (2,910)	1,298 (2,861)	863 (1,902)	1,300 (2,866)	1,300 (2,866)	1,300 (2,866)
Top speed, km/h (kts):						
at sea level	864 (467.0)	864 (467.0)	830 (448.64)	n.a.	900 (486.48)	872 (542)
at 3,000 m (9,842 ft)	n.a.	n.a.	n.a.	n.a.	950 (513.51)	n.a.
at 5,000 m (16,404 ft)	920 (497.29)	911 (492.43)	900 (486.48)	900 (486.48)	n.a.	965 (521.62)
Landing speed, km/h (kts)	200 (108.1)	170 (91.89)	165-180 (89.18-97.3)	n.a.	n.a.	166 (89.7)
Climb time to 5,000 m						
(16,404 ft), minutes	5.35	4.3	5.0	4.86	3.9	3.5
Rate of climb at S/L, m/sec (ft/min)	18.5 (3,640.8)	22.0 (4,329.6)	n.a.		24.0 (4,723.2)	28.0 (5,510.4)
Service ceiling, m (ft)	1,700 (? – S.K.)	13,500 (44,291)	13,000 (42,651)	13,100 (42,979)	13,000 (42,651)	14,000 (45,931)
Maximum range, km (miles)	810 (503)	800 (497)	n.a.	1,140 (708)	1,000 (621)	830 (515)
Take-off run, m (ft)	920 (3,018)	895 (2,936)	850 (2,788)	n.a.	850 (2,788)	640 (2,099)
Landing run, m (ft)	950 (3,116)	735 (2,411)	1,080 (3,543)	n.a.	740 (2,427)	920 (3,018)
Armament (calibre, mm)	1 x 57	1 x 37	1 x 37	1 x 37	1 x 37	1 x 37
				2 x 23	2 x 23	2 x 23

Notes:

1. The UTI MiG-9 and MiG-9M aircraft were not built in series.

2. Estimated performance figures (aircraft never flown).

3. In some documents a somewhat different figure is cited for the aircraft's length – 9.83 m (32.24 ft)

Chapter 2

The Jet 'Tadpoles'

of Aleksandr Yakovlev

OKB-115 headed by Vice People's Commissar of Aircraft Industry Aleksandr Sergeyevich Yakovlev was among the first to take on the task of developing jet fighters. The design bureau already had some experience with jet propulsion, having built and tested a number of mixed-power aircraft based on production or experimental piston-engined fighters during the Great Patriotic War; these featured ramjet boosters under the wings or a liquid-fuel rocket motor in the aft fuselage. In all cases, however, the speed increase turned out to be rather insignificant; also, the reliability of the boosters left something to be desired. The 'pure jet' Yak-7R (*reak**tiv**nyy* – jet-powered), a derivative of the production Yak-7 powered by two underwing DM-4S ramjets designed by Ivan A. Merkoolov and one D-1A liquid-fuel rocket motor designed by L. S. Dooshkin was developed in 1942; yet this aircraft never left the drawing board. Thus, the Yakovlev OKB's practical experience with jets in the first post-war years was extremely limited, as distinct from the rival OKB-155 led by Artyom I. Mikoyan which had built and tested the mixed-power I-250 fighter (*izdeliye* N) and the rocket-powered I-270 (*izdeliye* Zh) interceptor.

As already mentioned in the introductory section, when three Soviet aviation research establishments – GK NII VVS, LII and TsAGI – had evaluated several captured German jets, the results of these tests were distributed to the leaders of virtually all Soviet aviation design bureaux, including A. S. Yakovlev. Indeed, being Vice People's Commissar of Aircraft Industry, he was one of the first to receive these data – he was entitled to it. Yakovlev was one of the main opponents of copying the German designs completely, an idea floated by some in the commissariat. Besides, his design team had always favoured the lightweight single-engined agile fighter concept, whereas most of the German jet aircraft tested in the USSR were twinjets. Thus, OKB-115 decided to take a different road.

On 9th April 1945 the State Defence Committee issued a directive ordering the OKB of plant No. 115 (*sic*) to design, build and submit for testing a single-seat fighter powered by a *'Jumo 004 engine'*. In order to save time and fulfil the government orders as quickly as possible, the engineers selected the proven piston-engined Yak-3 as the starting point for the development of Yakovlev's first jet fighter. Retaining the low-wing, tailwheel-gear layout, the new fighter had the 900-kgp (1,984-lb st) Jumo 004B turbojet mounted beneath the forward fuselage so that the nozzle was located under the centre fuselage, resulting in a pod-and-boom arrangement. As recounted in Chapter One, this approach allowed the Yak-3's good field performance and agility to be retained.

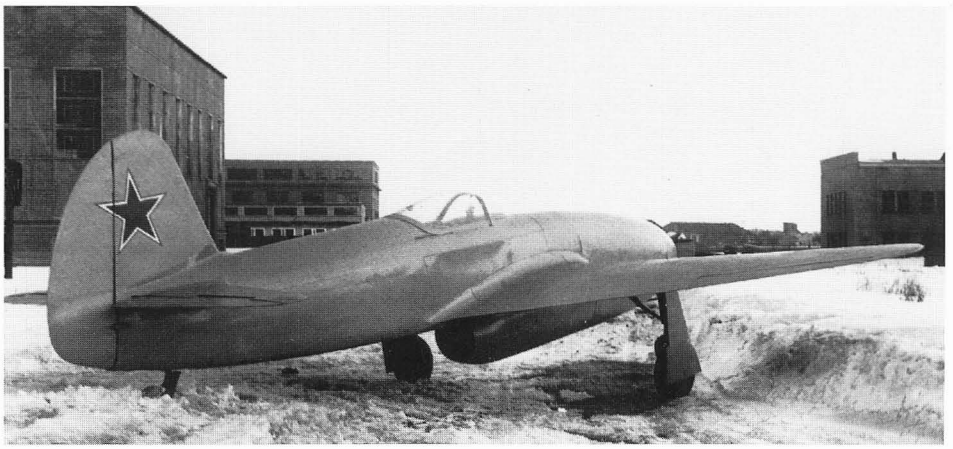
Structurally the fighter (provisionally designated **Yak-Jumo** or **Yak-3-Jumo** at this stage) was largely identical to the Yak-3 representative of the final production batches – ie, the all-metal version powered by the Klimov VK-107A engine. The fuselage was a welded steel tube truss skinned with duralumin; its front portion incorporated attachment points for the engine. A heat shield made of heat-resistant steel was installed under the centre fuselage to protect the skin from the jet blast.

The two-spar all-metal wings (which, because of the deeper forward fuselage, were now effectively mid-set rather than low-mounted) were built as a one-piece structure; the wing area was identical to that of the Yak-3, being 14.85 m² (159.67 sq. ft). The only major difference from the wings of the Yak-3 was that the front spar was bent to an inverted U shape at the wing/fuselage joint where it passed over the engine. The wings featured duralumin-skinned flaps and ailerons hinged to the rear spar. The front spar carried the main landing gear pivots; the inner portions of the wings accommodated the main fuel tanks. The oil cooler air intakes built into the Yak-3's wing leading edge at the roots were eliminated and a pitot tube was installed on the port wing near the tip.

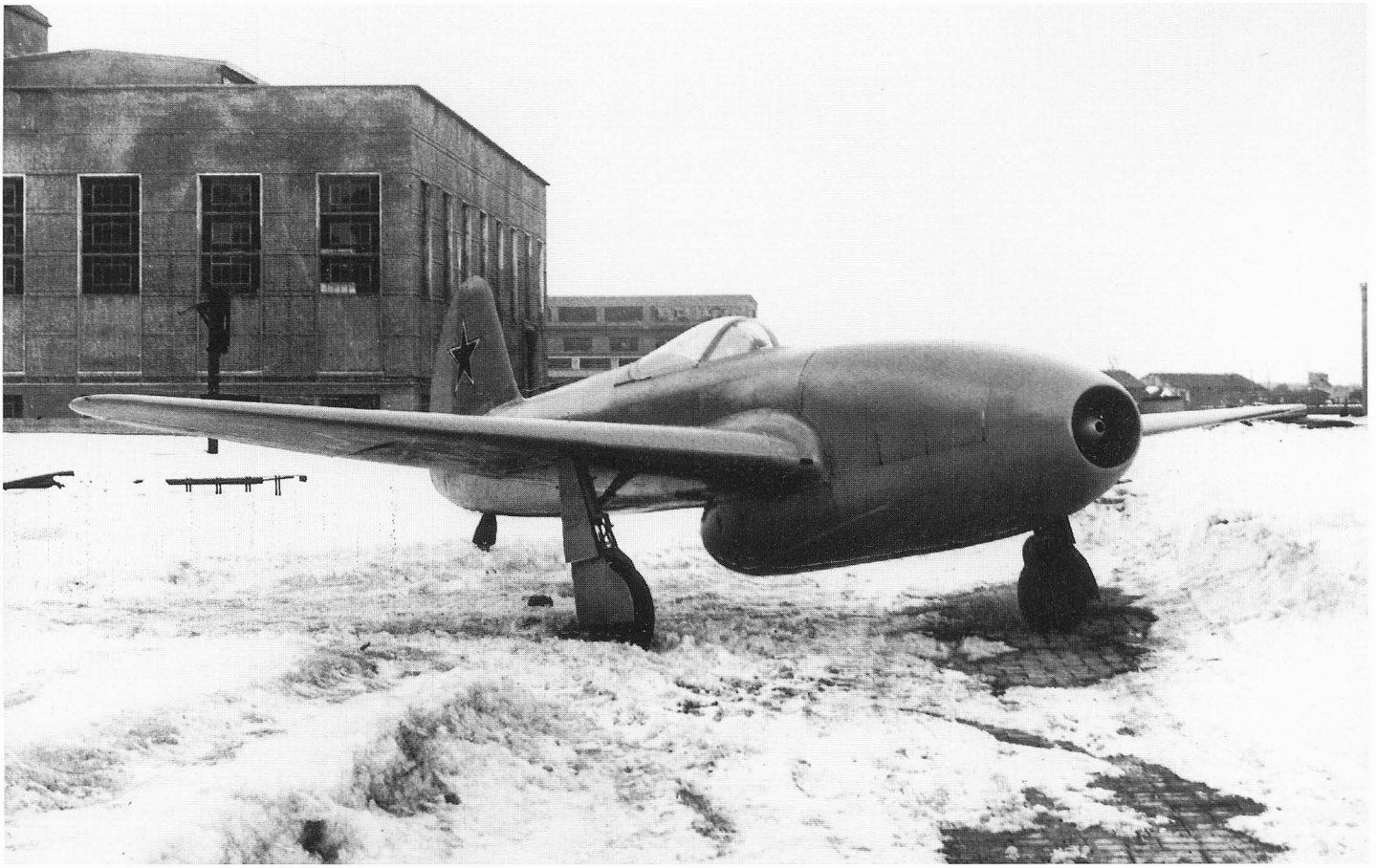
The cantilever tail surfaces were likewise of all-metal construction. The horizontal tail was taken straight from the Yak-3, but the area of the vertical tail was slightly increased. The rudder and elevators had a metal framework and a fabric skin.

The inward-retracting main gear units featured oleo-pneumatic shock absorbers and 600 x 180 mm (23.62 x 7.08-in.) wheels equipped with brakes. The aft-retracting tail strut with a 230x110 mm (9.05x4.33-in.) wheel was unusual in having a shock absorber made up of several compact steel leaf springs.

The cockpit (including the instrument panel), electric system and many other items and assemblies of the Yak-Jumo were completely identical to those of its piston-engined forebear. The cockpit was heated but not pressurised. Only minute changes were made to the tried and tested flight control system, pneumatic system (which operated the landing gear, flaps and wheel brakes) and avionics. As on the Yak-3, the armament was housed in the forward fuselage upper decking (above the engine); it consisted of two 23-mm (.90 calibre) Nudel'man/Sooranov NS-23 cannons. The fuel system comprised four tanks in the wings, a fifth tank in the forward fuselage above the engine and a small reserve fuel tank beneath the engine. Thus,



Yakovlev's first jet, the Yak-Jumo prototype, on the territory of plant No. 115 in Moscow.



Above and below: three-quarters front view and side view of the Yak-Jumo. Note the absence of cannons and the jet blast deflector on the rubber tailwheel; this measure turned out to be inadequate.

Above and below: The second prototype designated Yak15-RD10 seen during manufacturer's flight tests. The two cannons are clearly visible.

the Yak-Jumo was, in effect, a straightforward conversion of the Yak-3 to take a Jumo 004B turbojet.

As recounted in Chapter One, the State Defence Committee's directive 'On studying and mastering production of German jet aircraft designs' issued on 20th July 1945 required NKAP in general and several design bureaux in particular not only to launch production of the captured German turbojets but to create fighters powered by these engines – both matters ASAP. Being one of the bosses of the Soviet aircraft industry, Yakovlev was well aware of the importance of this task – and of the consequences for him and the other persons responsible, should they fail. Hence they prototype of the Yak-Jumo (called 'A. S. Yakovlev's experimental fighter' in some documents) was completed on time in October 1945; however, several blunders made by the designers became apparent as soon as the tests began. During the very first engine run the exhaust gases melted the duralumin skin of the lower fuselage beyond the heat shield (which turned out to be too short) and burned up the tailwheel; apparently nobody had realised that the tailwheel undercarriage was incompatible with the chosen engine placement and the rubber tire stood no chances in the hot exhaust! The aircraft had to be returned to the experimental plant for repairs and modifications which were completed in late December.

That same month the quality control department of MMZ No. 115 accepted the second prototype Yak-Jumo. It featured a new horizontal tail of increased area and an indestructible solid steel tailwheel. Five days after the rollout Yakovlev OKB test pilot Mikhail I. Ivanov started making taxi runs and short hops in this aircraft; soon, however, the second prototype was transferred to TsAGI for the purpose of performing full-scale wind tunnel tests. The fighter made numerous 'flights' in the T-101 wind tunnel with all possible combinations of true airspeed and angle of attack, and with the engine running at various speeds. This yielded valuable data on the change of longitudinal trim due to the thrust line being located below the aircraft's CG.

Learning from the many fatal accidents with early jets abroad (and the unfortunate statistics of the same kind accumulated in the USSR), the engineers gave a lot of thought to ensuring the structural integrity and reliability of Yakovlev's jet firstling. Sure enough, using the pod-and-boom arrangement and existing wing airfoils (which were rather thick, considering the high speeds for which the new fighter was designed) saved valuable time, but it also increased overall drag and imposed a strict limit on the top speed for structural strength reasons. During the wind tunnel tests the Yak-Jumo was examined not only by Air Force representatives and NKAP top brass but also by the heads of other Soviet aircraft design bureaux (who obviously learned a thing or two from this).

The wind tunnel research programme at TsAGI lasted until February 1946, whereupon the fighter was returned to LII's airfield to resume taxi trials. These were quite a sight; the solid steel tailwheel made a tremendous racket and struck sparks from the runway, but at least it did not burn up any more.

Ground tests and minor modifications based on the results of these lasted another month; at this stage the original engine, which turned out to be troublesome, was replaced with another Jumo 004B tested and approved by the Central Aero-Engine Institute (TsIAM – *Tsen**trahl**'nyy insti**toot** aviatsee**on**novo mo**tor**ostroy**en**iya*). The prototype's avionics and equipment included an RSI-6MU transmitter, an RSI-3M1 receiver, a GS-15-500 generator, a 12-A-10 DC battery and a KP-14 breathing apparatus with a 2-litre (0.44 Imp. gal.) oxygen bottle. The aircraft's CG range was 21.7% to 17.7% mean aerodynamic chord (MAC).

On 26th February, when the Yak-Jumo was still undergoing ground tests, the Council of People's Commissars issued yet another directive (No. 472-191ss). This document defined the main assignments for the Soviet 'fighter makers' regarding jet fighter development, set the deadlines by which the new fighters were to enter flight test and required NKAP to concentrate on the eminently important tasks of *'...dramatically improving the flight performance of development aircraft and creating new models of aircraft'*. The appropriate MAP order No. 162ss appeared on 27th March (by then the Council of People's Commissars had been reorganised into the Council of Ministers, and all the People's Commissariats were accordingly renamed into ministries). This document said:

'...Chief Designer and Director of plant No. 115 A. S. Yakovlev [...] shall design and build [...] a single-seat fighter powered by a Jumo 004 engine, with the following characteristics:

- *maximum speed at sea level, 770 km/h (416.21 kts);*
- *maximum speed at 5,000 m, (16,404 ft), 850 km/h (459.45 kts);*
- *range at 0.9 V_{max}, 500 km (310.5 miles);*
- *endurance at 0.9 V_{max}, 40 minutes;*
- *endurance in optimum cruise mode, 60 minutes;*
- *climb time to 5,000 m (16,404 ft), 4.5 minutes;*
- *service ceiling, 14,500 m (47,572 ft);*
- *armament, two 23-mm (.90 calibre) cannons.*

Two prototypes are to be built, the first of which shall be ready for flight testing on 1st September 1946.'

In the spring of 1946 the efforts of the Soviet Union's two leading fighter design bureaux finally bore fruit. As recounted in the preceding chapter, the first pure jet aircraft developed by Mikoyan's OKB-155 (the I-300) and Yakovlev's OKB-115 (the Yak-Jumo) successfully made their maiden flights on the same day, 24th April. Taking off at 13:56 Moscow time – several hours after the I-300 – with Mikhail I. Ivanov at the controls, the Yak made a single circuit of the airfield and landed. Thus, seven months had elapsed from the rollout to the first real flight.

There have been assertions in the popular press that the pilots swapped planes that same day, with Ivanov flying the I-300 and Mikoyan OKB test pilot Aleksey N. Grinchik flying the Yak-Jumo, and that Grinchik praised the Yakovlev fighter after the flight, especially its easy and pleasant handling. No documentary proof of this has been found to date; what **is** known, however, is the fact that the I-300 made its second flight on 7th May, not 24th April! Of course, it is possible that such an exchange did take place after all, but if it did, it was certainly at a later date.

Officially the manufacturer's flight tests of Yakovlev's jet fighter, which had by then acquired a spate of official and semi-official designations (it was referred to in various documents as the **Yak-15**, **Yak15-RD10** (*sic*) or even **Yak-RD**), began on 9th April, continuing until 22nd June 1946. M. I. Ivanov was project test pilot and Yevgeniy G. Adler was the engineer in charge of the test programme. The protocol on the results of the tests said that the fighter was *'a version of the Yak3-VK107A'* and was *'cleared for flight tests with a never-exceed speed of Mach 0.7'*. The specifications of the Yak-Jumo (Yak15-RD10) prototype as recorded during the manufacturer's flight tests are given in the table on page 51.

Elated by this success, A. S. Yakovlev hastened to report that the assignment to design a single-seat jet fighter had been successfully accomplished. Prompted by Yakovlev, on 29th April 1946 the Council of Ministers issued directive No. 952-397ss followed by MAP order No. 282ss to the same effect on 8th May. These documents officially tasked OKB-115 with developing and building a single-seat fighter powered by the Soviet-built version of the Jumo 004B – the RD-10. The aircraft was to have a top speed of 770 km/h (416.21 kts) at sea level and 850 km/h (459.45 kts) at 5,000 m (16,404 ft), reaching this altitude in 4.5 minutes. Range in optimum cruise mode was to be 700 km (437 miles), the service ceiling was to be 14,000 m (45,931 ft) and the take-off run no more than 600 m (1,968 ft). As before, the specified armament consisted of two 23-mm cannons.

Once again, two prototypes were to be manufactured, the first aircraft entering flight test in the third quarter of 1946. This tight

schedule probably suited Yakovlev fine, since he had chosen the easy way – even though he was aware that this design approach would hardly yield good results. As it were, both prototypes were already completed, requiring only new engines to be installed; conversely, the competing design bureaux were at least several months behind in their attempts to create jet fighters (with the exception of the Mikoyan OKB, with which it was a neck-to-neck race). One can hardly blame Yakovlev for wanting to be the first past the post; besides, the Soviet Air Force urgently needed jet fighters, and every little bit helped. Yakovlev's fighter could fill the void until something better was available.

As already noted, the manufacturer's flight tests of the Yak15-RD10 (this rather cumbersome appellation was soon changed to **Yak-15**, under which designation the fighter was ultimately to enter service) ended in June 1946. Thus, despite the pressure put by the government on the aircraft industry, only two jet fighters – the I-300 (by then officially designated MiG-9) and the Yak-15 – were ready for the traditional Tushino flypast in August 1946; the Yak-15 was flown by Mikhail I. Ivanov on that occasion. After this event the fighter was allocated the NATO reporting name *Feather*.

As a result of the important government assignment facing serious delays (many more jets were to have participated in this flypast), on 12th September MAP let loose with an order, demanding that small batches of production jet fighters – at least two aircraft of each model – be manufactured, test-flown and transferred to GK NII VVS for State acceptance trials in time to take part in the 7th November parade in Moscow's Red Square.

Curiously, pursuant to the government directive the first 15 production Yak-15s earmarked for the said parade were to be manufactured sans armament and cockpit armour, with a full-size forward fuselage fuel tank (installing the cannons would require the capacity of this tank to be reduced) and an incomplete avionics fit. As recounted in the previous chapter, the day after the MiG-9's and Yak-15's Tushino debut – ie, almost a full month before the abovementioned directive appeared – Iosif V. Stalin summoned Chief Designers A. I. Mikoyan and A. S. Yakovlev to the Kremlin and personally instructed them to build fifteen copies of each fighter with a view to displaying them publicly at the 7th November parade.

The Tbilisi aircraft factory (plant No. 31) was chosen to build the Yak-15; it was still turning out Yak-3s at the time, which undoubtedly was one of the reasons for the choice. The added workload of manufacturing the Yak-15s meant the plant had to work almost round the clock to cope with the task; yet cope it did, meeting the deadline – thanks not least to the considerable structural commonality between the two types. All fifteen aircraft were assembled and test-flown in time for the parade; eventually, however, the flying display had to be cancelled due to bad weather.

Yak-Jumo (Yak15-RD10) specifications

Powerplant	RD-10 (Jumo 004 type) *
Thrust at sea level/at 5,000 m (16,404 ft), kgp (lb st)	900/550 (1,984/1,212)
Length overall	8.7 m (28 ft 6.52 in.)
Wing span	9.2 m (30 ft 2.2 in.)
Stabilizer span	2.8 m (9 ft 2.23 in.)
Wing area, m² (sq. ft)	14.85 (159.67)
Horizontal tail area, m² (sq. ft)	2.8 (30.1)
Vertical tail area, m² (sq. ft)	1.86 (20.0)
Empty weight, kg (lb)	1,985 (4,376)
Payload, kg (lb)	585 (1,289)
All-up weight, kg (lb)	2,570 (5,665)
Fuel load, kg (lb)	472 (1,040)
Wing loading, kg/m² (lb/sq. ft)	174 (35.72)
Power loading at sea level/at 5,000 m (16,404 ft), kg/kgp (lb/lb st)	2.85/4.67
Top speed, km/h (kts):	
at sea level	770 (416.21)
at 3,000 m (9,842 ft)	790 (427.0)
at 5,000 m (16,404 ft)	800 (432.43)
Landing speed, km/h (kts)	150 (81)
Time to height, minutes:	
to 5,000 m (16,404 ft)	3.1
to 10,000 m (32,808 ft)	12.3 **
Rate of climb, m/sec (ft/min):	
at sea level	24.0 (4,723)
at 5,000 m	14.5 (2,853)
at 10,000 m	5.0 (984)
Service ceiling, m (ft)	13,700 (44,947) **
Maximum range at N = 8,700 rpm/8,100 rpm, km (miles):	
at 3,000 m (9,842 ft)	330/375 (205/233)
at 5,000 m (16,404 ft)	385/400 (239/248)
at 8,000 m (26,246 ft)	500/575 (310.5/357)
Maximum design endurance at N = 8,700 rpm/8,100 rpm, minutes:	
at 3,000 m (9,842 ft)	28/36
at 5,000 m (16,404 ft)	36/44
at 8,000 m (26,246 ft)	50/60
Take-off run, m (ft)	520 (1,706)
Landing run, m (ft)	480 (1,574)
Armament	2 x NS-23 w. 60 rpg

Notes:

** This is how the engine type is stated in the manufacturer's flight tests protocol.*

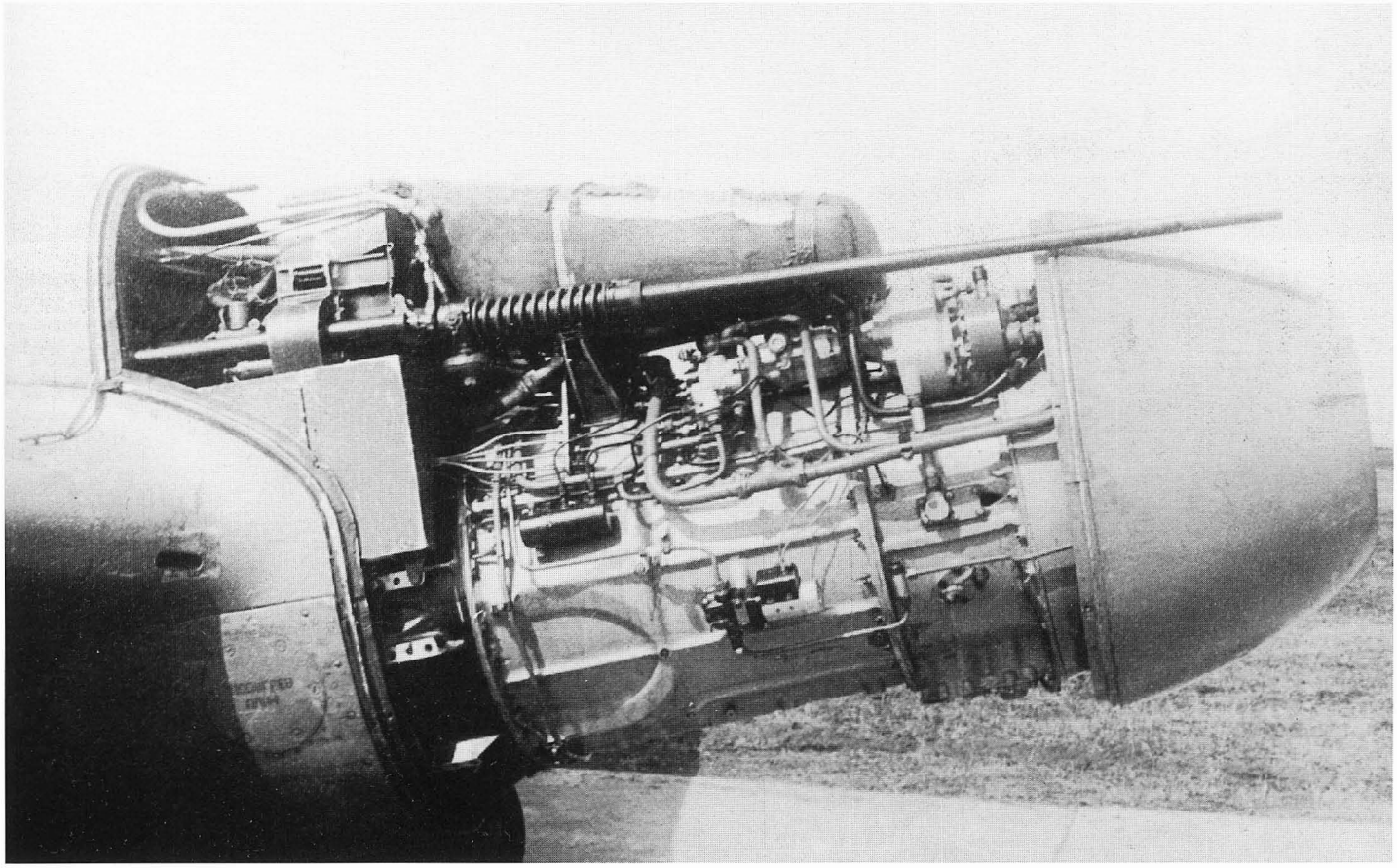
*** Calculated for a theoretical engine speed (N) of 8,700 rpm, as the engine refused to run at high rpm above 6,000 m (19,685 ft).*

The autumn of 1946 was a hectic time for plant No. 31. Not only did the enterprise have to master jet aircraft production and complete the initial production batch of single-seat Yak-15s within the shortest time possible but it was also ordered to urgently build and prepare for testing the prototype of the two-seat trainer version described later. Since the trainer's development schedule was slipping catastrophically, this aircraft was laid down first, receiving the construction number 31001 (ie, plant No. 31, 001st Yak-15 built there).

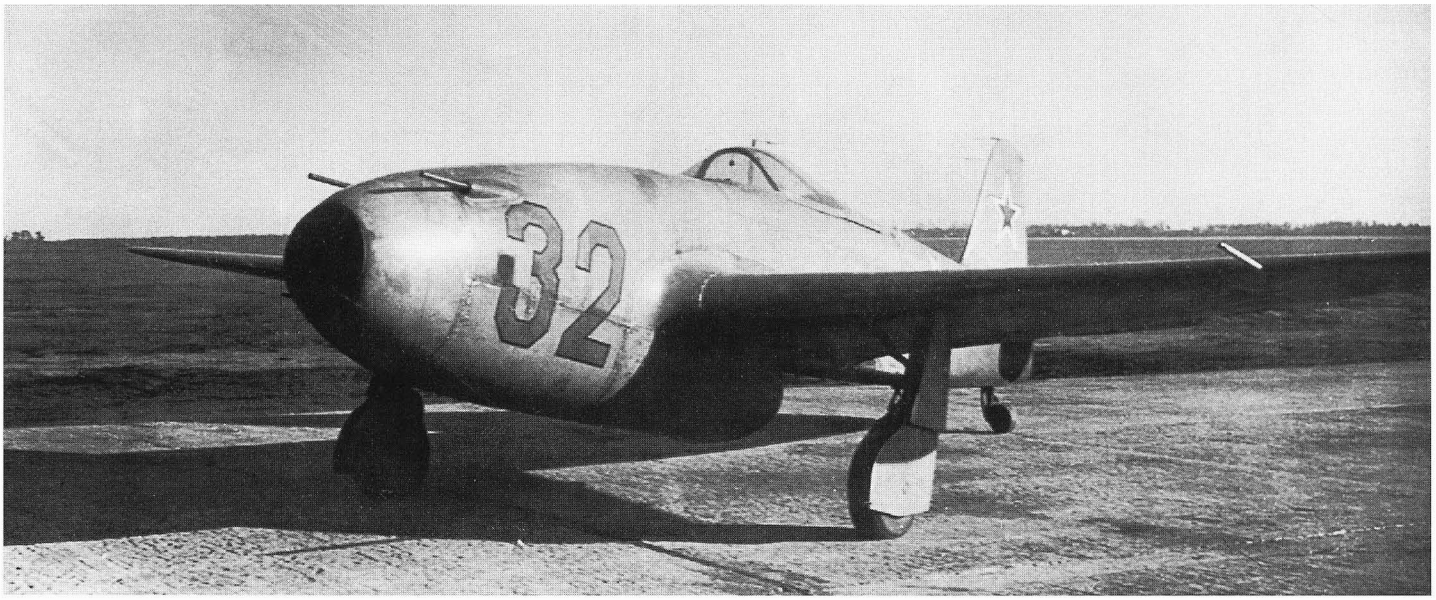
The next aircraft in the sequence was the first production single-seater (c/n 31002) which received the serial 32 Red; this fighter and the final aircraft of the initial production batch (35 Red, c/n 31015) were delivered to GK NII VVS for State acceptance trials. Both fighters were armed with a single NS-23 cannon on the starboard side. The all-up weight varied from 2,638 to 2,742 kg (5,815-6,045 lb); the latter option included 90 kg (198 lb) for the pilot, 580 kg (1,278 lb) of jet fuel, 14 kg (30 lb) of petrol for the start-up system, 11 kg (24.25 lb) of engine oil, 37 kg (81.5 lb) for the cannon, 23 kg (50.7 lb) of ammunition and 25 kg (55 lb) of removable equipment. The State acceptance trials, which lasted until April 1947, were performed by Air Force test pilots G. A. Sedov and A. G. Proshakov; the latter

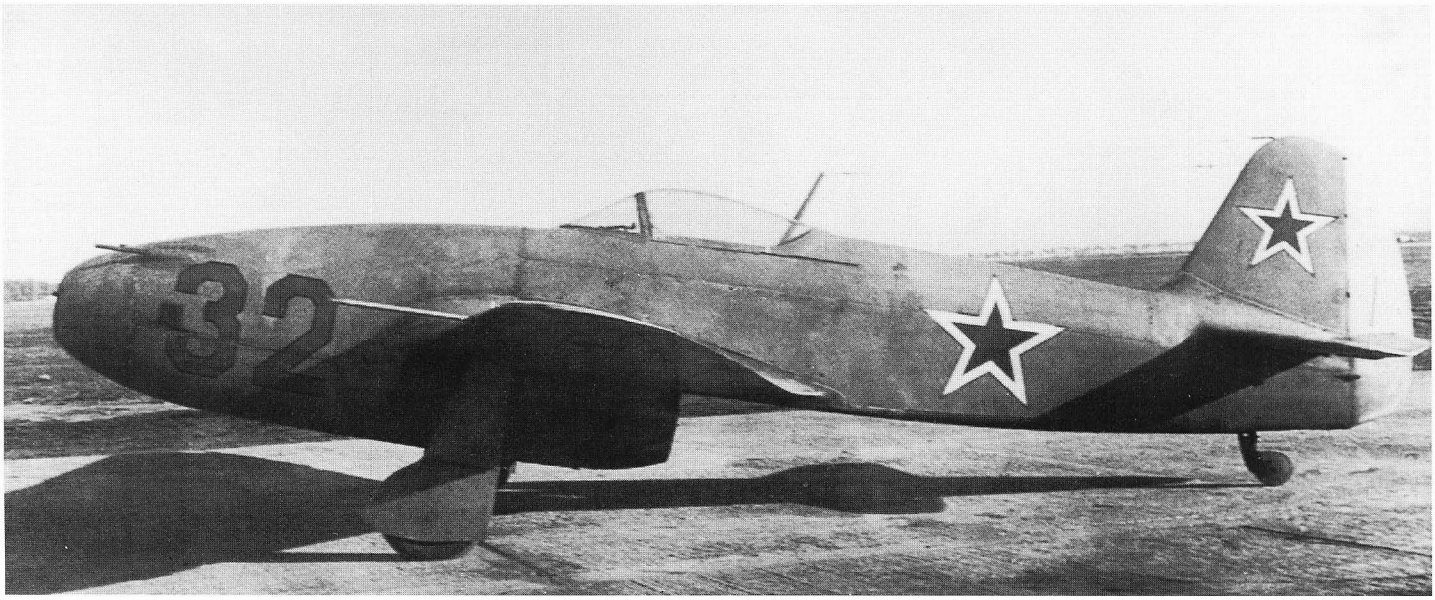
Above and below: The 15th production Yak-15 (35 Yellow, c/n 31015) at GK NII VVS during State acceptance trials. The fighter was built with a single NS-23 cannon on the starboard side.

Above: A three-quarters rear view of Yak-15 c/n 31015. Note the DF loop aerial aft of the cockpit.



The forward fuselage of Yak-15 c/n 31015 with the cowling removed, showing the cannon installation and the upper fuel tank.



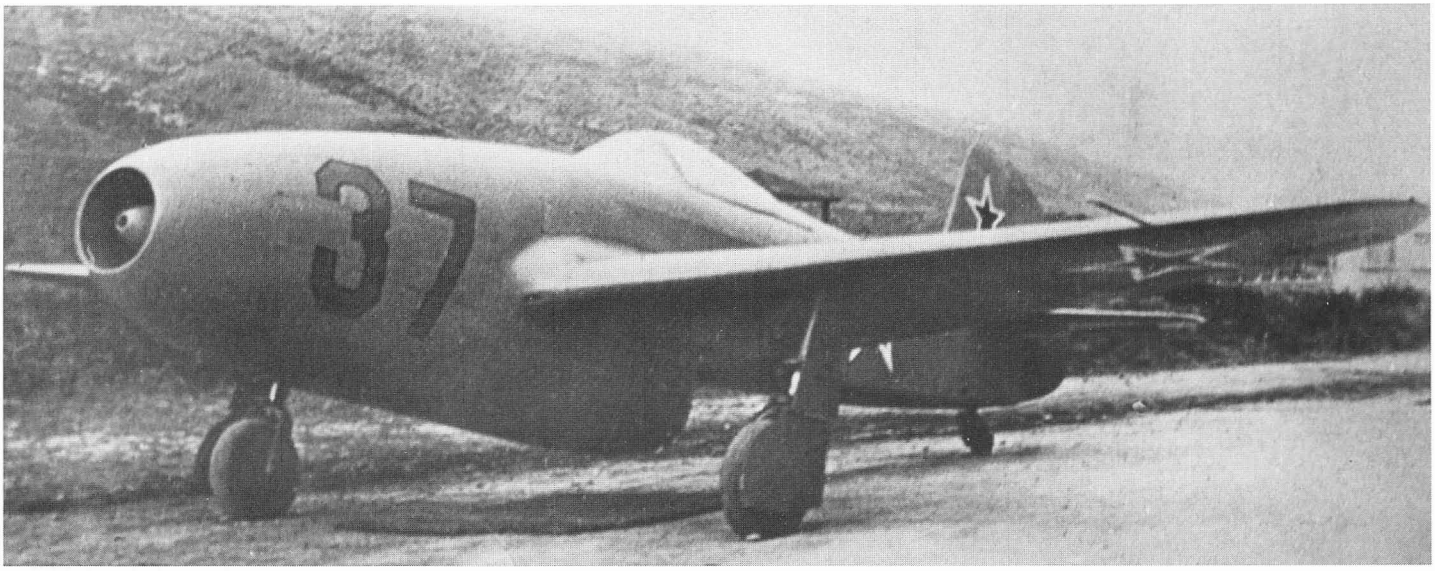


Top and above: Yak-15 '32 Yellow' (c/n 31002) seen during State acceptance trials following modifications.

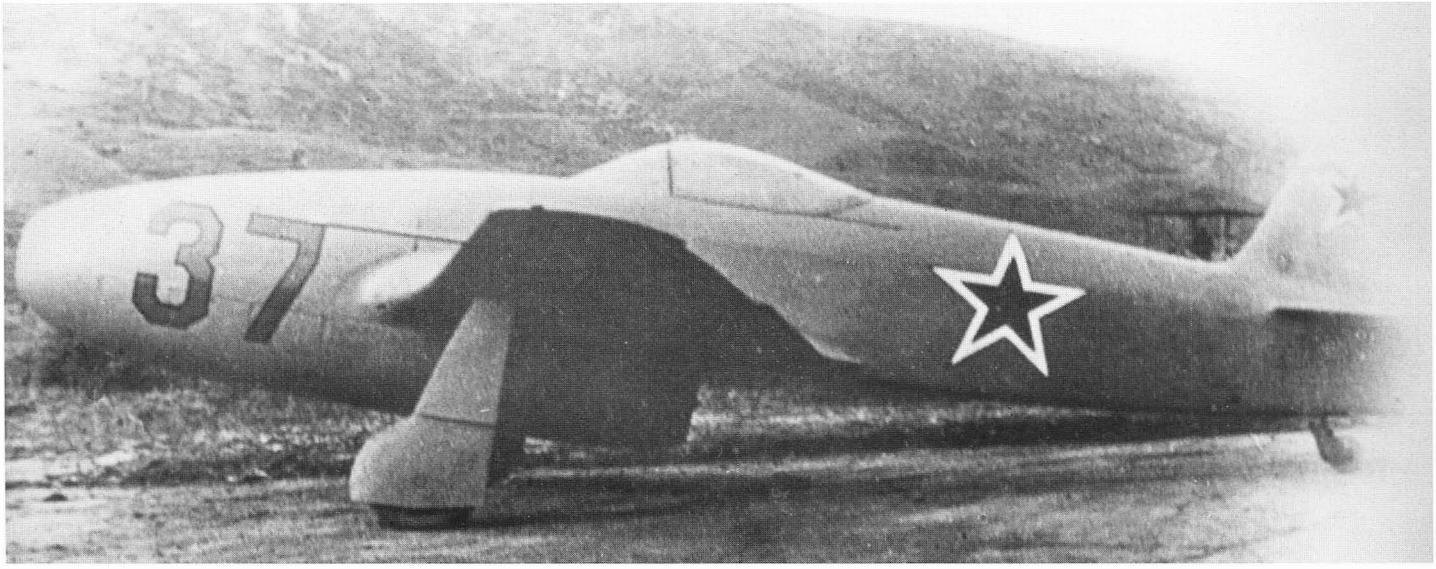
Left: A flight of initial-production Yak-15s seen during a rehearsal of the 7th November 1946 military parade.

Top and above: Two views of Yak-15 '57 Yellow' during checkout trials at GK NII VVS. The yellow numeral '2' on the rudder did not mean anything at all and was intended to confuse would-be spies.

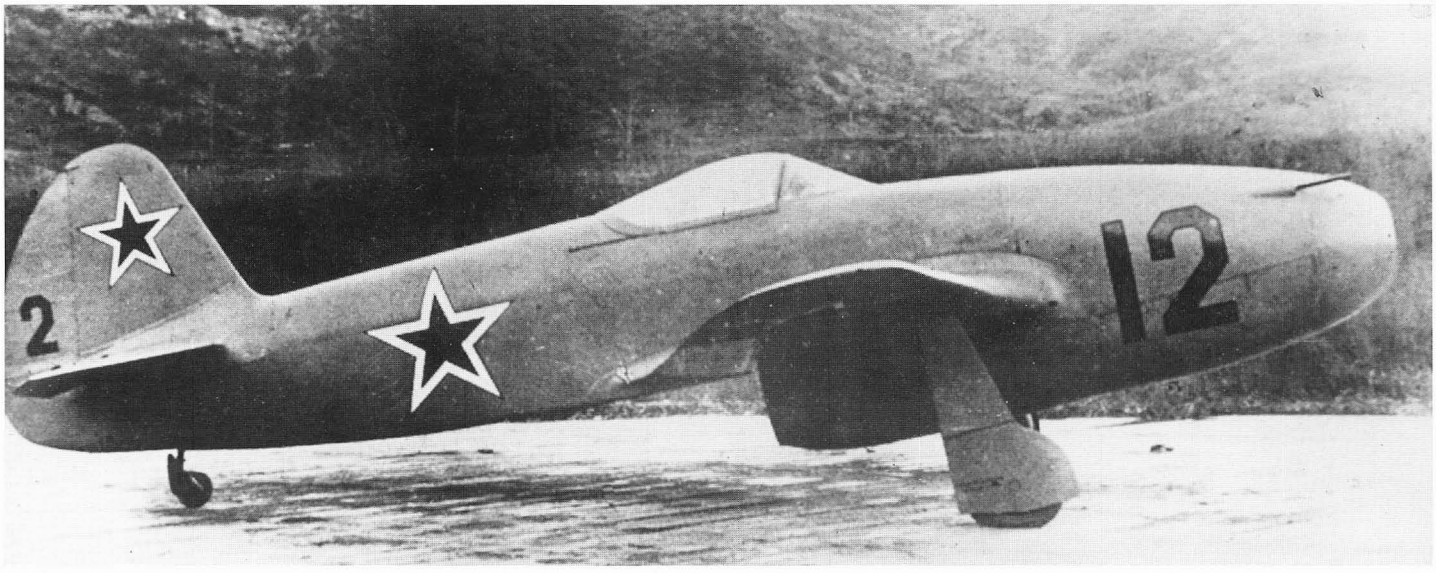
Right: Birds of a *Feather* flock together? A group of Soviet Air Force pilots watches a trio of Yak-15 perform group aerobatics.



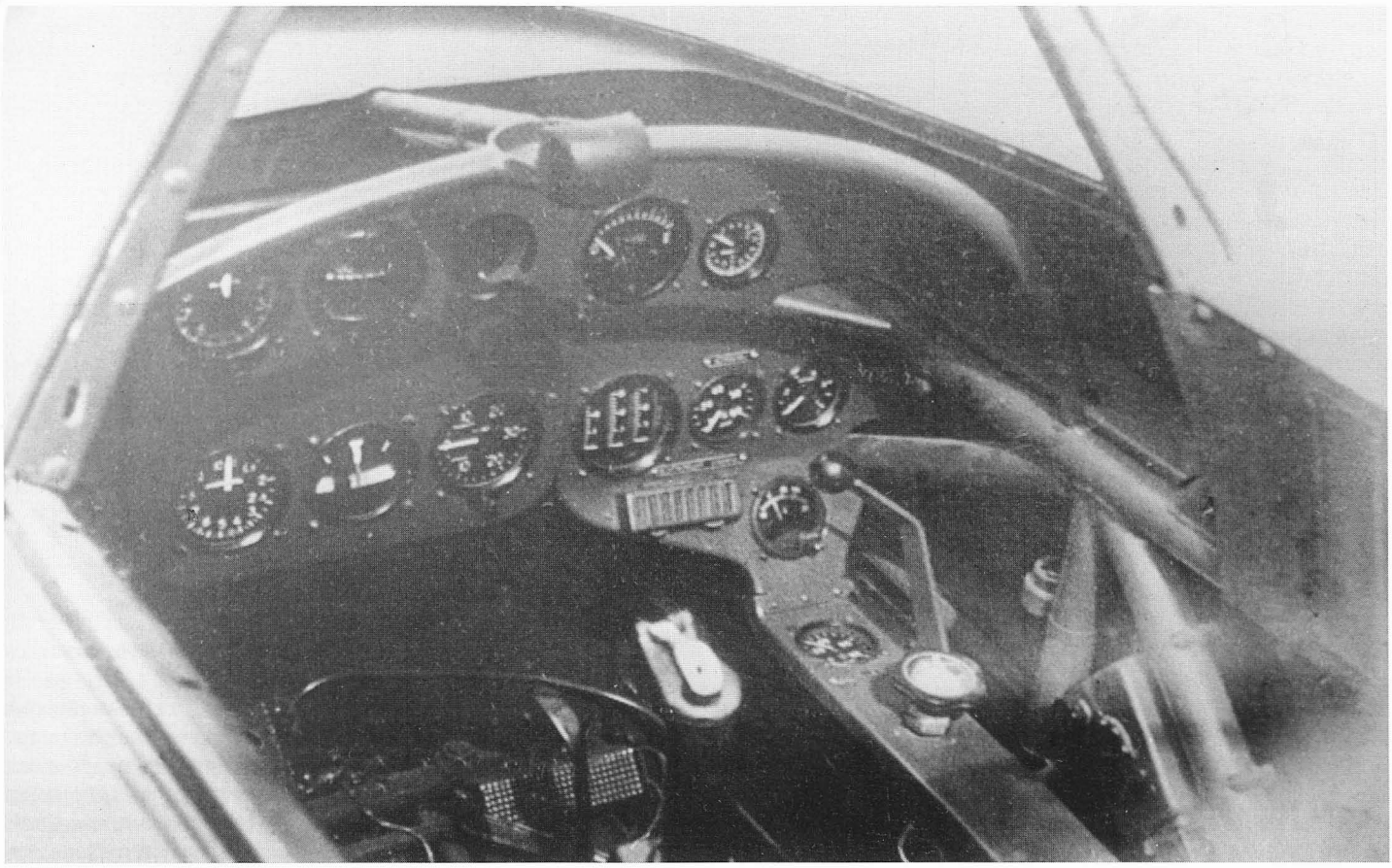
Above: 37 Yellow, one of the Yak-15s of the initial-production ('parade') batch. Note the absence of cannons.



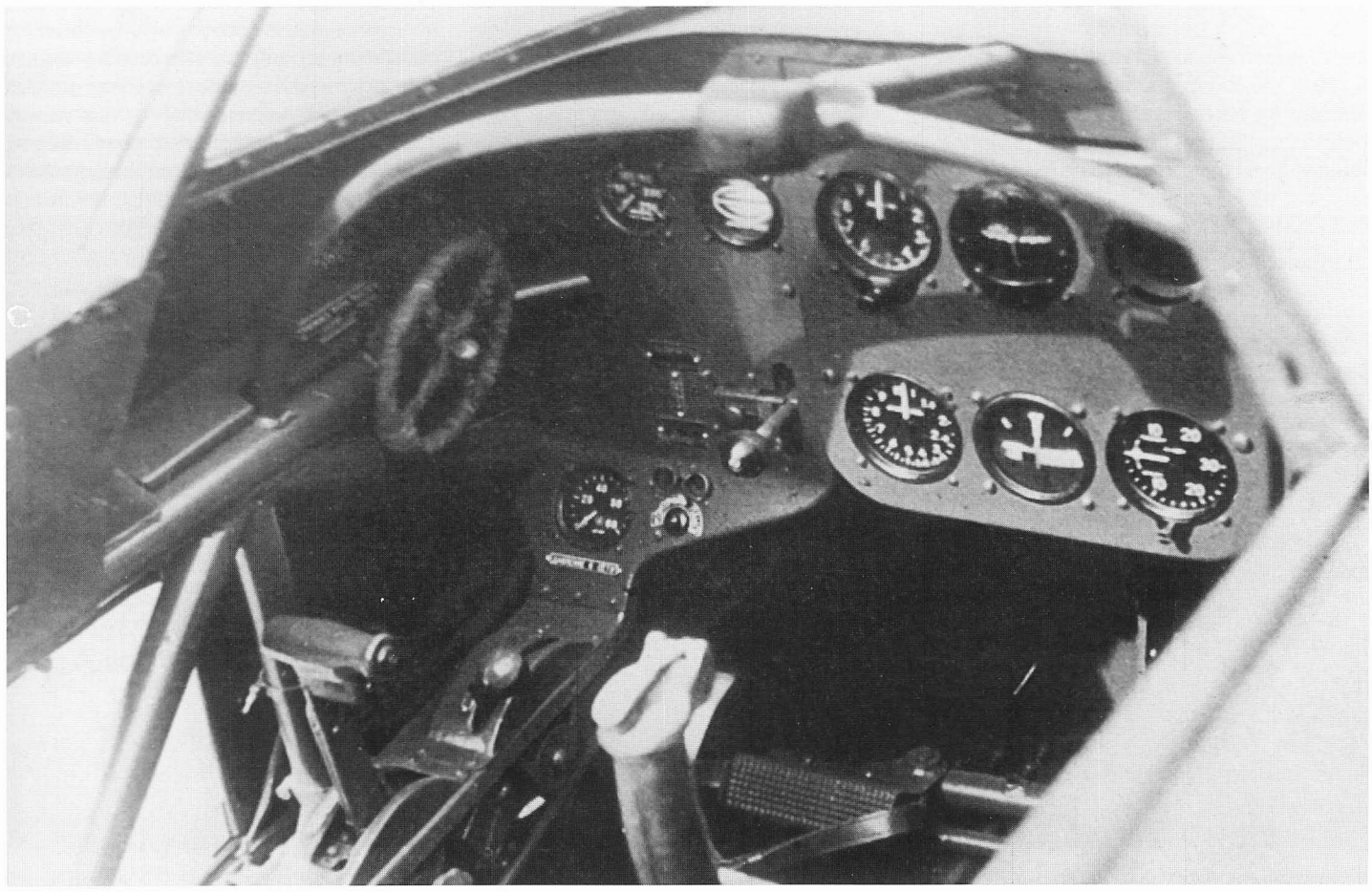
Left: Another view of the same aircraft, with the Major Caucasus Ridge as a backdrop.



12 Yellow, an early-production Yak-15, on the factory apron in Tbilisi. The aircraft is again marked '2 Yellow' on the rudder.



Above and below: The cockpit of an early-production Yak-15. The U-shaped 'handle' above the instrument panel is part of the fuselage framework.

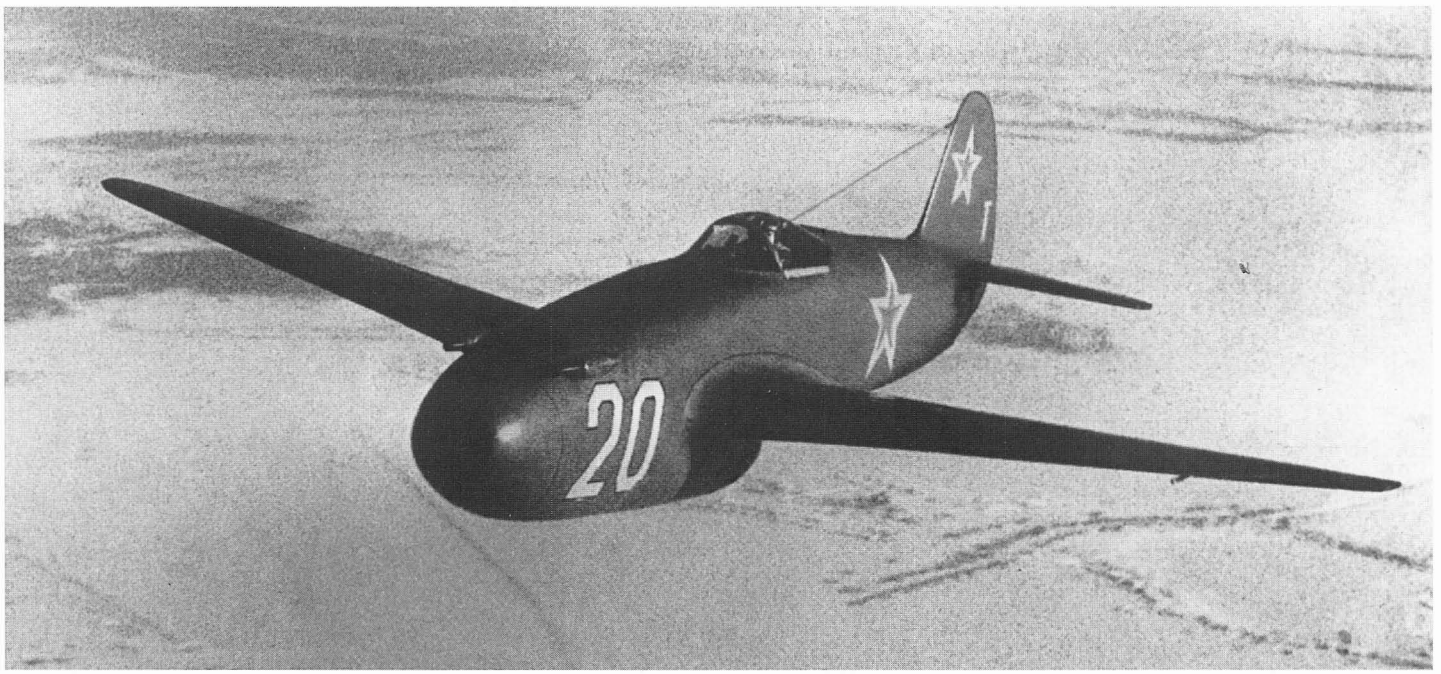


Following the recommendations of GK NII VVS, the Soviet Air Force used the Yak-15 as a training aircraft to ease the transition to more capable jet fighters.

was also the institute's engineer in charge of the Yak-15's trials.

Predictably, the fighter's performance was inferior not only to that of the MiG-9 (I-300) but also to that of the captured Messerschmitt Me 262A-1a evaluated by GK NII VVS in late 1945. The drag generated by the thick wing airfoil ate up a lot of speed, preventing the aircraft from making full use of the engine's thrust; on production Yak-15s top speed was limited to 700 km/h (378 kts) below 3,150 m (10,334 ft) and Mach 0.68 at higher altitudes for structural strength reasons. The powerplant itself was a whole can of worms; three engine changes had to be made on the two aircraft in the course of the State acceptance trials, and frequent engine troubles (the RD-10 could not run at nominal power for more than ten minutes) prevented GK NII VVS from establishing the fighter's performance throughout the altitude envelope. Ascent in maximum rate-of-climb mode was only permitted up to 8,370 m (27,460 ft) in order to avoid damaging the engine; besides, due to the engine's limitations the service ceiling turned out to be only 10,000 m (32,808 ft) instead of the estimated 12,000 m (39,370 ft).

The military also voiced a long list of complaints regarding the design. Among other things, the metal tailwheel caused the rudder (and hence the rudder pedals) to vibrate during taxiing. When the engine was ground-run it kicked up stones, damaging the elevators; the underside of the horizontal tail iced up during prolonged taxiing on snow-covered airfields (quite simply, the snow melted in the exhaust stream and the water then froze up on the cold stabilizer skin); the jet blast eroded the airfield surface etc. The chief source of annoyance was the smoke which entered the cockpit during long missions (20-25 minutes), irritating the pilot's eyes; even flying goggles were of no avail against it. The problem was caused by fuel and oil perpetually leaking onto the engine (which required frequent



A famous picture of a production Yak-15 in flight.

maintenance and repairs) and then decomposing when the engine got hot, emitting smoke.

The long and short of it was that GK NII VVS demanded that modifications be made to the fighter. To give credit were credit is due, the military were not just complaining – they performed what modifications they could themselves (among other things, GK NII VVS specialists replaced the original radio's single-wire aerial with a twin-wire aerial to increase reception range). In the State acceptance trials protocol concerning Yak-15s c/ns 31002 and 31015 the State commission suggested equipping the Yak-15 with a new tricycle landing gear, modifying the horizontal tail and installing special fuel tanks to ensure stable engine operation under negative G loads.

Concurrently with the State acceptance trials another Yak-15 (c/n 31009) underwent a special test programme in order to establish the type's aerobatic capabilities. GK NII VVS test pilot Pyotr M. Stefanovskiy performed the first aerobatics session in this aircraft on 25th February 1947. Of all Soviet jet fighters existing in the spring of 1947 the Yak-15 was easiest to fly, presenting no problems for the average fighter pilot; airmen who had flown the Yak-3 transitioned to its jet stablemate without any trouble. As a combat aircraft, however, the Feather did not live up to expectations as regards longitudinal stability and controllability (the insufficient elevator authority was especially disappointing); also, an unpleasant side effect of the pod-and-boom arrangement was the marked change in stick forces from the elevators when the throttle was advanced or retarded.

Despite the shortcomings described above, the fighter received a generally positive appraisal. The aforementioned protocol signed in May 1947 said:

'The Yak-15 aircraft [...] meets the Air Force's requirements for a jet fighter trainer... (sic); [...]

Due to the extremely short range of only 300 km (186 miles) in optimum cruise at 1,000 m (3,280 ft) *[...] it is inexpedient to develop the aircraft into a fully-capable combat type, since this will impair its handling and manoeuvrability due to [...] the much higher all-up weight resulting from the additional fuel required to provide a range of 800-900 km* (497-559 miles).

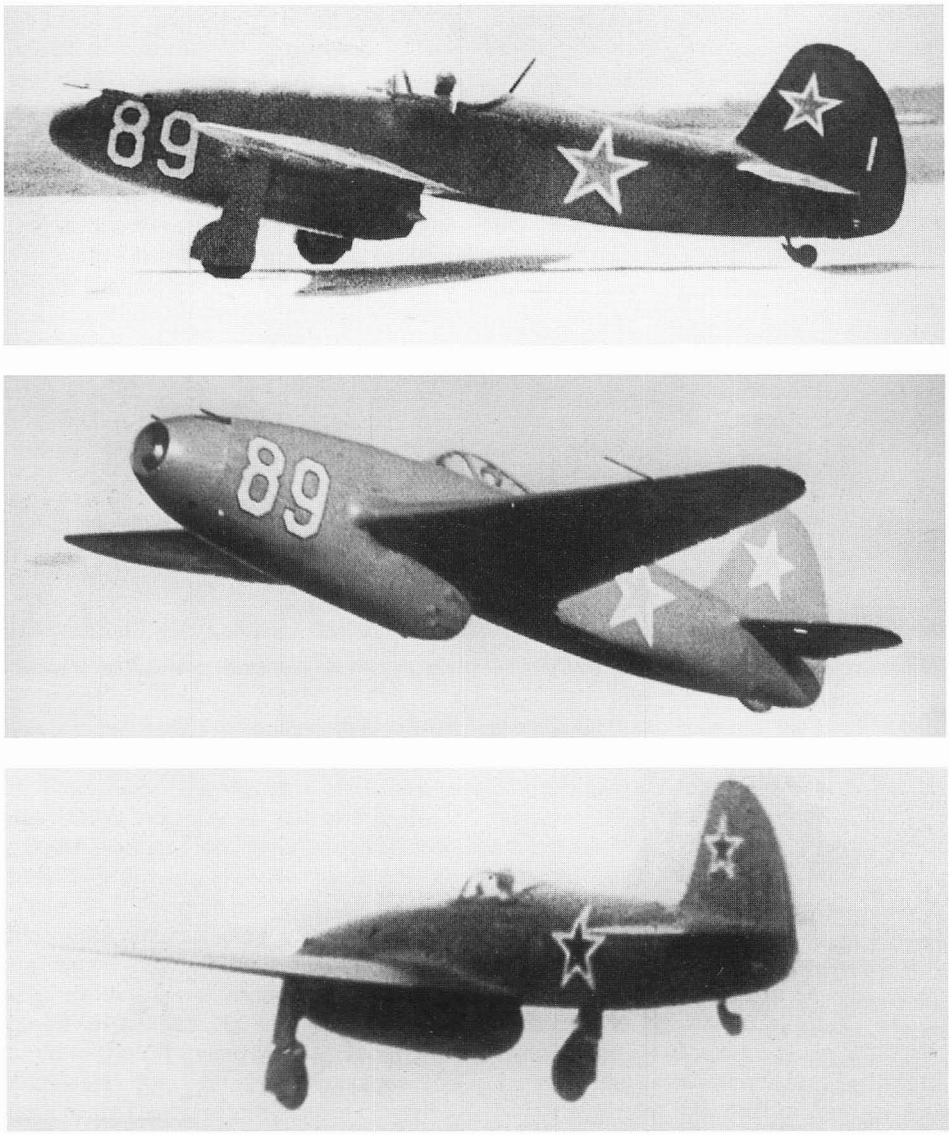
Because of the simple design, low thrust of the RD-10 engine and simple piloting techniques the State commission considers it advisable [...] to develop the Yak-15 into a dual-control trainer with a tricycle landing gear...'

Thus, the decision to launch production of the Yak-15 was dictated solely by its commonality with the Yak-3. The big idea was that the type would be used as a stepping stone from piston-engined fighters to more capable ('real') jet fighters and as a proficiency trainer.

The table on this page provides a performance comparison of three jet fighters tested by GK NII VVS during the first two post-war years.

On 16th December 1946, when the State acceptance trials were still in progress, the Council of Ministers issued directive No. 2698-1114ss, the appropriate MAP order No. 801ss following ten days later. These documents ordered the ministry's 1st Main Directorate chief Ter-Markaryan and the Tbilisi aircraft factory's director V. Saladze to build and deliver to the Air Force 50 Yak-15 fighters powered by RD-10 turbojets; 25 of these were to be standard single-seat aircraft and the rest were to be completed as dual-control trainers with a reduced armament fit. The production schedule was spelled out very specifically: plant No. 31 was to manufacture five fighters in January 1947, fifteen in February, 20 aircraft in March (including 15 two-seaters) and the final ten (all of them trainers) in April. Thus,

	Me 262A-1a WNr 110 426	**Yak-15 c/ns 31002, 31015**	**MiG-9**
Trials completion date	November 1945	April 1947	June 1947
Powerplant	2 x Jumo 004B	1 x RD-10	2 x RD-20
Thrust, kgp (lb st)	2 x 900 (2 x 1,984)	900 (1,984)	2 x 800 (2 x 1,763)
Empty weight, kg (lb)	n.a.	1,852 (4,082)	n.a.
Normal all-up weight, kg (lb)	6,026 (13,284)	2,638-2,742 (5,815-6,045)	4,998-5,054 (11,018-11,142)
Wing loading, kg/m² (lb/sq. ft)	280 (57.49)	177-185 (36.34-37.98)	274-278 (56.26-57.08)
Power loading, kg/kgp (lb/lb st)	3.34	3.05	3.16
Top speed, km/h (kts):			
at sea level	780 (421.62)	700 (378.37)	864 (467.0)
at 3,150 m (10,334 ft)	n.a.	805 (435.13)	n.a.
at 5,000 m (16,404 ft)	841 (454.59)	786 (424.86)	910 (491.89)
at 10,000 m (32,808 ft)	834 (450.81)	735 (397.30)	853 (461.0)
Landing speed, km/h (kts)	164 (88.6)	135 (73.0)	170 (91.9)
Stalling speed, km/h (kts):			
in 'clean' configuration	n.a.	160 (86.48)	n.a.
in landing configuration	n.a.	125 (67.56)	n.a.
Time to height, minutes:			
to 5,000 m (16,404 ft)	4.2	4.8	4.3
to 10,000 m (32,808 ft)	12.9	13.8	10.8
Rate of climb at sea level, m/sec (ft/min)	n.a.	21.6 (4,250.8)	n.a.
360° turn time at 500 m (1,640 ft), seconds	n.a.	26	37-39
Maximum range, km (miles):			
at 1,000 m (3,842 ft)	n.a.	300 (186)	550 (341)
at 5,000 m (16,404 ft)	680 (422)	454 (282)	705 (437.8)
at 8,000 m (26,246 ft)	n.a.	510 (316)	n.a.
at 10,000 m (32,808 ft)	n.a.	n.a.	800 (496.8)
Endurance:			
at 1,000 m	n.a.	39 min	1 hr 13 min
at 5,000 m	1 hr 5 min	59 min	1 hr 34 min
at 8,000 m	n.a.	1 hr 4 min	n.a.
at 10,000 m	n.a.	n.a.	1 hr 21 min
Take-off run, m (ft)	1,025 (3,362)	600 (1,968)	950 (3,116)
Take-off distance, m (ft)	n.a.	1,380 (4,527)	n.a.
Landing run, m (ft)	1,075 (3,526)	530 (1,738)	1,060 (3,477)
Landing distance, m (ft)	n.a.	1,050 (3,444)	n.a.
Armament (cannons)	4 x 30-mm (1.18 cal.) w. 90 rpg	1 x 23-mm (.90 cal.) w. 60 rounds	1 – 37-mm (1.45 cal) w. 40 rounds + 2 x 23-mm (.90 cal.) w. 80 rpg
G limit	n.a.	+2.9	+2.5-2.85



Stills from a ciné film showing a production Yak-15 during take-off (top, centre) and landing.

by the end of April 1947 MAP planned to deliver a total of 65 Yak-15s with Soviet-built engines. As of 31st December 1946 the plant had built the fifteen unarmed examples mentioned earlier (the ones which were to participate in the 7th November parade), and another eight Yak-15s were in various stages of manufacturing.

The engines powering production Yak-15s were produced by aero-engine plant No. 26 in Ufa; the first production examples were in fact assembled from original Jumo 004B1 components delivered from Germany by way of reparations for the damage inflicted during the war. The RD-10 had a ten-stage axial compressor (hence the relatively small casing diameter), six straight-through combustion chambers and a single-stage axial turbine. The nozzle area was adjusted by a translating cone (centrebody) according to engine rpm. Starting was by means of a two-stroke two-cylinder Riedel engine, which in turn was started electrically or manually (by means of a cord). Officially (according to the engine ID cards) the time between overhauls (TBO) of the first production RD-10s was only 25 hours; in reality, however, it was even less, being an appalling 17 hours at best. Still, during this brief period the engine's reliability was reasonably high.

In January 1947, when the Yak-15 was undergoing State acceptance trials, Vice Minister of Aircraft Industry Pyotr V. Dement'yev wrote to the Air Force's Chief Engineer Markov, expressing his ideas about Yak-15 production:

'I believe that the 65 Yak-15s with RD-10 engines currently being manufactured by plant No. 31 for the May Day parade shall be completed to exactly the same standard as the ones [...] built for the 7th November 1946 parade, ie, without armament and cockpit armour, with a full-size upper kerosene tank (the reference to kerosene is due to the fact that, as the reader remembers, there was also a petrol tank for the start-up system – *Auth.*), *[...] with a [communications] radio receiver and transmitter but no RPKO-10M direction finder...*

The NS-23K cannon and the RPKO-10M have failed to pass State acceptance trials and are not manufactured in series. On these aircraft all the defects discovered in the course of preparations for the 7th November [1946] parade, as listed in your report, will be eliminated.

After delivering 65 aircraft [...] in the configuration stated above plant No. 31 will start manufacturing aircraft equipped with armament, cockpit armour and a DF with a flat (ie, buried) *loop aerial.'*

Thus by the early summer of 1947 the Soviet Air Force had more than 50 Yak-15 fighters on strength – or rather in service, since some of them were in reality not fighters at all, lacking armament or having but one cannon. Anyway, the buildup of the Soviet jet fighter force was demonstrated to good effect on 1st May 1947 when 50 Yak-15s and 50 MiG-9s streaked over the Red Square. That year also saw the Soviet Union's first aerobatics displays performed by jet aircraft, including the *Feather*. Even before GK NII VVS had officially pronounced the type fully aerobatic, service pilots had illegally performed aerobatics in the Yak-15 at the Soviet Air Force's Conversion training centre. Now, Col. I. Poloonin was the first to perform solo aerobatics in a Yak-15 in front of the watching crowds at Tushino; this was followed by a breathtaking aerobatics display by a flight of Yak-15s led by Lt. Col. N. I. Khramov, Hero of the Soviet Union.

The 1948 Tushino air display featured aerobatics performed by assorted jets flown by I. Poloonin, Yuriy A. Antipov, A. G. Proshakov and other Air Force pilots. By then Gen. Yevgeniy Ya. Savitskiy, twice Hero of the Soviet Union, had organised a display team flying the Yak-15; it was staffed by four well-known military pilots – P. Sereda (HSU), N. I. Khramov, V. Yefremov and P. Solov'yov. At the 1949 Tushino event group aerobatics were performed by a quintet of Yak-15s led by Col. P. Choopikov (HSU).

Production of the type ended in 1947 after a total of 280 Yak-15s had rolled off the assembly line in Tbilisi. Most of them remained in Air Force service for a few more years. The most widespread malfunctions occurring in service included seepage of oil from the main gear oleos, snapping of individual wires in the rudder control cable and breakage of the tailwheel strut's leaf springs (probably caused by overheating of the wheel).

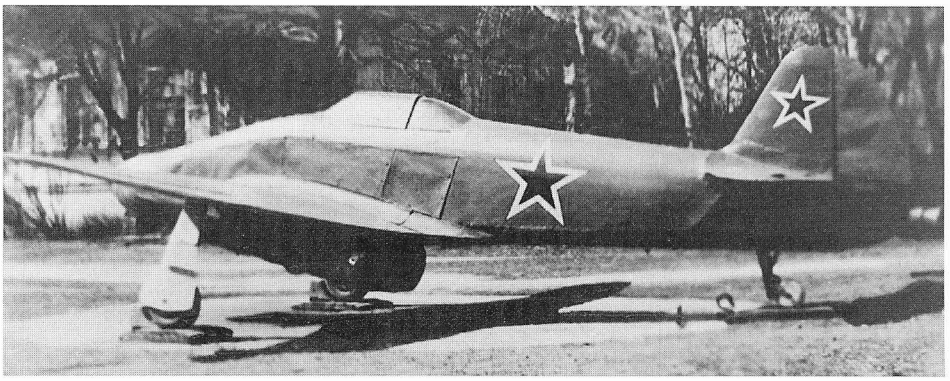
As noted earlier, the Yak-15's chief shortcoming was its extremely limited range which was less than half that of piston-engined fighters due to the RD-10's high fuel consumption.

With a full fuel load of 590 kg (1,300 lb) the Yak-15 had a range of only 510 km (316 miles); in contrast, the Yak-3 whose full fuel load was only 350 kg (771 lb) had a maximum range of 1,060 km (658 miles)! This problem became especially acute when preparations for the 1947 May Day parade got underway. During formation flying the 50 Yak-15s drank up their fuel supply in just 30 minutes; this not only required the fighters' route to and from the Red Square to be carefully planned but also meant that large groups of aircraft had to take off at minimum intervals, which placed certain demands on the pilots' flying skills.

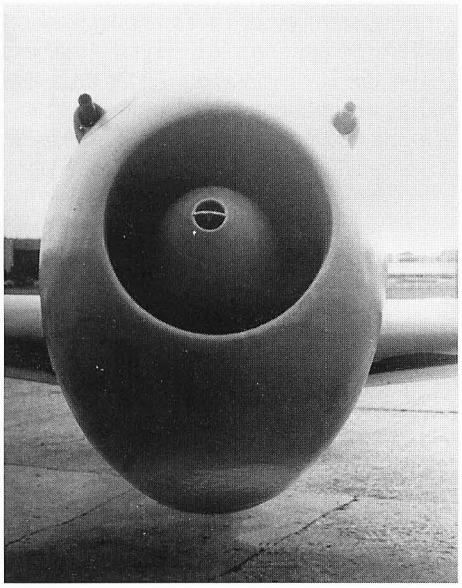
Despite all its limitations, the Yak-15 is nevertheless not to be dismissed so easily. In its day it played an important role, helping to train hundreds of jet fighter pilots who later transitioned to the much more capable MiG-15. Speaking of which, the unavailability of the two-seat trainer version of the Yak-15 (the 25 two-seaters mentioned earlier which plant No. 31 was to complete by April 1947 were never built) led some Soviet Air Force units to convert a few single-seat Yak-15s to dual-control trainers without bothering about authorisation from the OKB or the factory. The Yak-15 was the first jet aircraft officially included into the Soviet Air Force inventory – and the first jet fighter on which VVS pilots performed aerobatics.

The *Feather* became the progenitor of a small family of fighters which, though none too popular with the pilots who flew them, saw service not only with the VVS but also with the air arms of some of the Soviet Union's allies. Speaking of which, as early as 1947 the Polish Air Force's acquisition plans included the purchase of jet fighters (most probably Yak-15s) from the USSR; however, these plans did not materialise until a little later when the Yak-17 came on the scene.

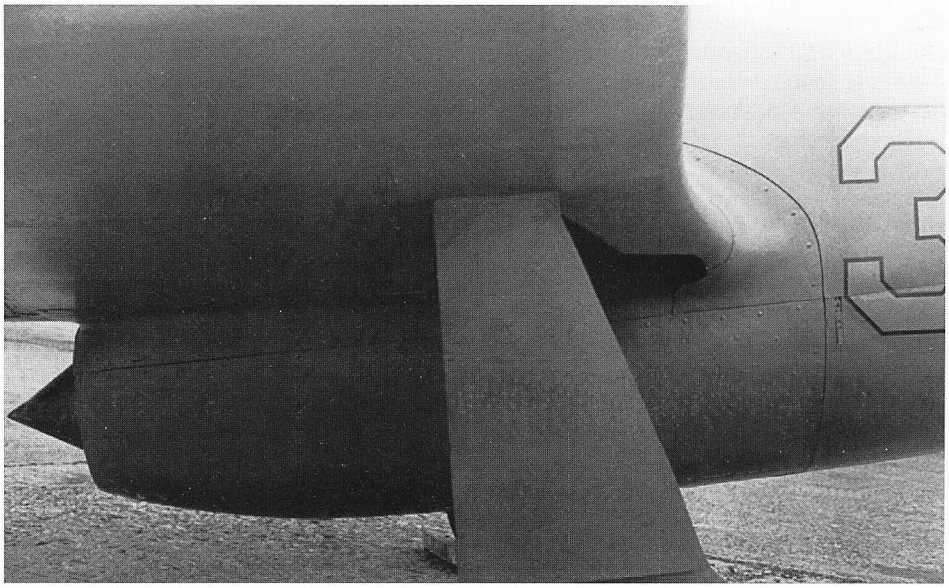
Above: A Soviet Air Force pilot clad in a leather topcoat and leather flying helmet with goggles poses beside his Yak-15. Unusually, this aircraft is equipped with a gun camera on top of the windscreen.



Above: Looking rather battered and sporting a non-standard three-piece canopy, this Yak-15 was preserved at one of the Soviet fighter bases.



The engine air intake and the cannon muzzles.



The nozzle of the RD-10; the pointed centrebody projects noticeably from it in the fully aft position.

Some Western sources claim that on 10th May 1953 a Yak-15 was shot down in Korea by a US Air Force (319th Fighter Interceptor Squadron) Lockheed F-94 Starfire flown by Capt. D. Phillips. However, this is nonsense, as Yakovlev jets never participated in the Korean War. (A possible explanation is that someone mistakenly wrote 'Yak-15' instead of 'MiG-15'.)

Only a single Yak-15 survives in Russia; on the other hand, it is in pristine condition. Coded 37 Yellow, this aircraft was probably a development machine owned by the Yakovlev OKB and is now preserved in the company museum. The fighter left the museum's premises at least twice to be displayed publicly during airshows (at Tushino in August 1977 and at Moscow-Khodynka in August 1989).

Now we have to travel back in time a little. On 29th April 1946, three days after the maiden flights of the I-300 and Yak-Jumo prototypes, the Council of Ministers issued directive No. 952-397ss ordering Chief Designer and Director of plant No. 115 Yakovlev to develop and build a new single-seat fighter powered by an RD-10 turbojet and featuring improved aerodynamics. The directive specified a top speed of 850 km/h (459.45 kts) at 5,000 m (16,404 ft) and a range increased from the Yak-Jumo's 500 km (310.5 miles) to 700 km (437 miles) at 0.9 V_{max}. The appropriate MAP order No. 278s 'On the manufacturer's flight tests of A. S. Yakovlev's experimental fighter with an RD-10 engine' followed on 7th May.

The advanced development project of the aircraft provisionally designated **Yak17-RD10** did not take long to complete. (In some documents the fighter was referred to simply as the **Yak-RD** or **Yak-RD10**.) Outwardly the new fighter closely resembled the original Yak15-RD10 (Yak-15) but incorporated major changes, featuring redesigned wings of a different planform employing high-speed laminar airfoils, redesigned tail surfaces of increased area and an ejection seat. The latter had an armoured back; the pilot was also protected by a 55-mm (2.16-in.) bulletproof windscreen. Because of the new airfoils the wings were too thin to accommodate the mainwheels. Hence the main gear units had to be redesigned; they were attached to one of the fuselage mainframes, retracting aft into the fuselage in a rather complex fashion , and featured a levered suspension with leading arms. The mainwheel size remained the same as on the Yak-15 (600 x 180 mm/23.62 x 7.08 in.) but the metal tailwheel was widened considerably to 230 x 180 mm (9.05 x 7.08 in.) and the landing gear track was narrowed to only 2.0 m (6 ft 7 in.). The cockpit canopy was also redesigned.

Two wing versions with an area of 15.0 m² (161.29 sq. ft) and 13.5 m² (145.16 sq. ft) respectively were considered for the Yak17-RD10. The avionics and equipment suite was standard for Soviet fighters of the period. It included a radio set with an RSI-6 transmitter and RSI-6M receiver, an RPKO-10M direction finder, an SCh-3 IFF transponder (SCh stands for *svoy/choo**zhoy***, = friend/foe), a PBP-1A gunsight, a GS-15-500 DC generator, a 12-A-10 DC battery and a KP-14 breathing apparatus with a 2-litre (0.44 Imp. gal.) oxygen bottle. The fighter's basic design specifications are stated in the table below.

Powerplant	RD-10
Thrust at sea level/ at 8,700 m (28,543 ft), kgp (lb st)	900/440 (1,984/970)
Length overall	8.4 m (27 ft 6.7 in.)
Height on ground	2.5 m (8 ft 2.42 in.)
Wing span	9.1 m (29 ft 10.26 in.)
Stabilizer span	2.92 m (9 ft 6.96 in.)
Wing area, m² (sq. ft)	15.0 (161.29)
Horizontal tail area, m² (sq. ft)	2.92 (31.39)
Vertical tail area, m² (sq. ft)	1.95 (20.96)
Empty weight, kg (lb)	1,945 (4,288)
Payload, kg (lb)	755 (1,664)
All-up weight, kg (lb)	2,700 (5,952)
Fuel load, kg (lb)	650 (1,433)
Wing loading, kg/m² (lb/sq. ft)	180 (878)
Power loading at sea level/ at 8,700 m (28,543 ft), kg/kgp (lb/lb st)	3.0/6.14
Top speed, km/h (kts):	
at sea level	780 (421.62)
at 5,000 m (16,404 ft)	822 (444.32)
at 7,000 m (22,965 ft)	830 (448.64) *
Landing speed, km/h (kts)	160 (86)
Service ceiling, m (ft)	14,000 (45,931)
Maximum range, km (miles)	700 (434)
Take-off run, m (ft)	500-550 (1,640-1,804)
Landing run, m (ft)	480 (1,574)
Armament	2 x NS-23 w. 100 rpg

** Note: For the version with the smaller 13.5-m2 wings, the estimated top speed at 7,000 m was 850 km/h (459.45 kts).*

Prototype construction proceeded quickly; the aircraft was rolled out on 3rd September 1946 and the first flight date was tentatively set for 20th September. However, the ground tests dragged on until 26th September and were terminated after OKB test pilot G. S. Klimooshkin had made a few taxi runs. Theoretically the thinner wings would have given the Yak17-RD10 a certain speed advantage over the Yak15-RD10; however, the latter had already been ordered into production and the tailwheel landing gear was outdated anyway. Therefore, the Yak17-RD10 remained in prototype form and the designation Yak-17 was eventually reallocated to a closely related but different aircraft described later in this chapter.

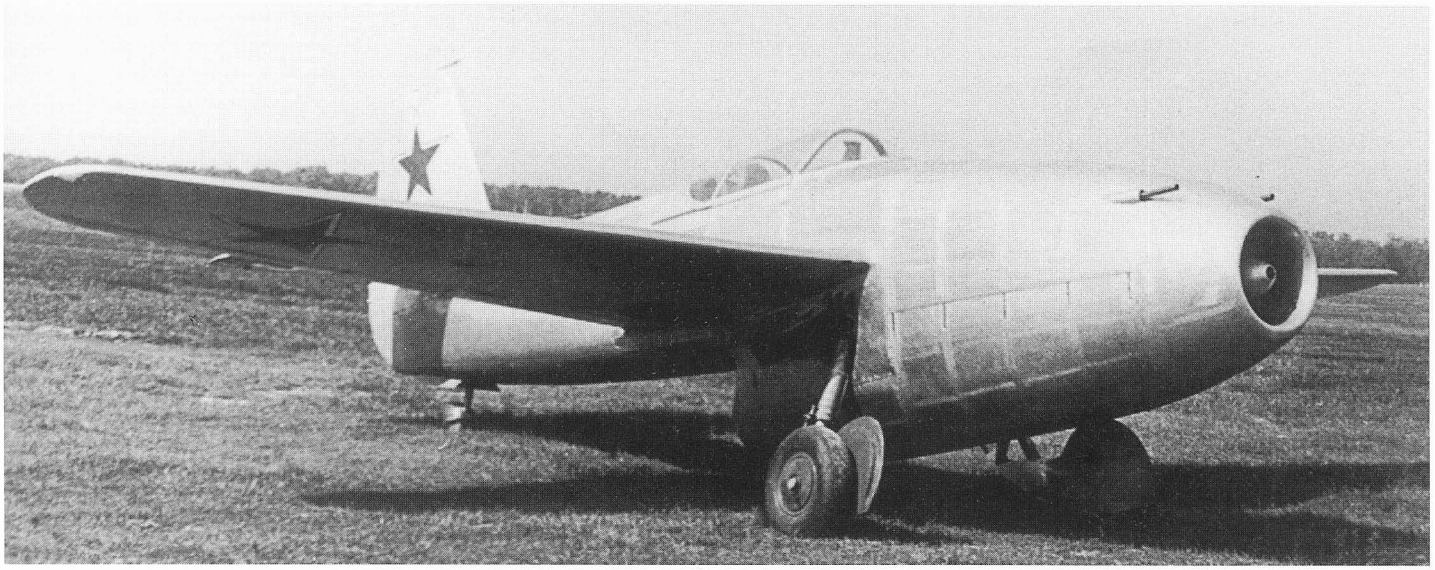
A production Yak-15 serialled 47 Yellow was used by LII as a **refuelling system testbed** in the late 1940s. In 1948 a design team at LII headed by Vladimir Sergeyevich Vakhmistrov (this engineer had gained fame in the 1930s for his fighter/bomber combinations called *zveno* – flight, as a tactical unit) developed an in-flight refuelling (IFR) system. The tanker and the receiver aircraft deployed special cables which became intertwined due to the tanker making certain manoeuvres. Then a hose would be unwound from the tanker's wing or fuselage and the cable rewound until the hose engaged a receptacle under the receiver aircraft's wingtip. Once the hose had been locked securely into position, gravity fuel transfer could begin.

Soon afterwards, however, LII test pilots Igor' Shelest and Viktor Vasyanin developed and proposed a slightly different system at their own risk. They rightly believed that the complex IFR procedure should be simplified and automated as much as possible. The Shelest/Vasyanin system involved flying on parallel courses, which meant the receiver aircraft did not need to enter the tanker's wake turbulence which might lead to loss of control. The tanker deployed a hose stabilised by a small parachute from one wing and the receiver aircraft placed its opposite wing over the hose. After that, the hose was rewound until a fitting at the end engaged the receptacle. The receiver then increased speed so that the hose formed a loop and rotated the receptacle, opening a valve. Another important difference was that fuel was transferred under pressure, which considerably speeded up the process.

The Soviet Air Force top brass decided that the Shelest/Vasyanin system held promise, so a pair of Tu-2 bombers were set aside for conversion into IFR system testbeds with a dummy installation. Flight tests with these aircraft began in the summer of 1949; later the abovementioned Yak-15 '47 Yellow' was similarly outfitted with a dummy receptacle, making contact with the Tu-2 'tanker'.

As mentioned earlier, even though it had been decided to relegate the Yak-15 to the conversion trainer role, a dual-control version of the fighter was sorely needed. As far back as 9th July 1946, when the Yak-15 had yet to commence State acceptance trials, the Council of Ministers issued directive No. 1498-665s concerning *'...development of dual-control trainers in order to facilitate the transition of fighter pilots to the new jet hardware'*. MAP order No. 525s to the same effect was signed on 6th August; among other things, it said:

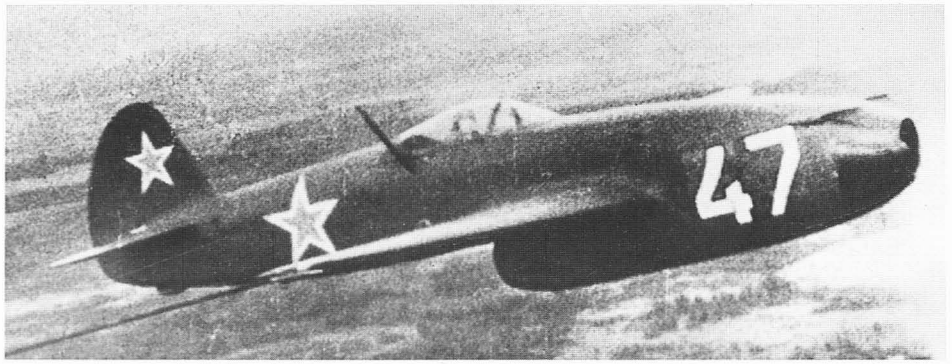
'1. Chief Designer A. S. Yakovlev shall [...] develop and build a single prototype of [...] a



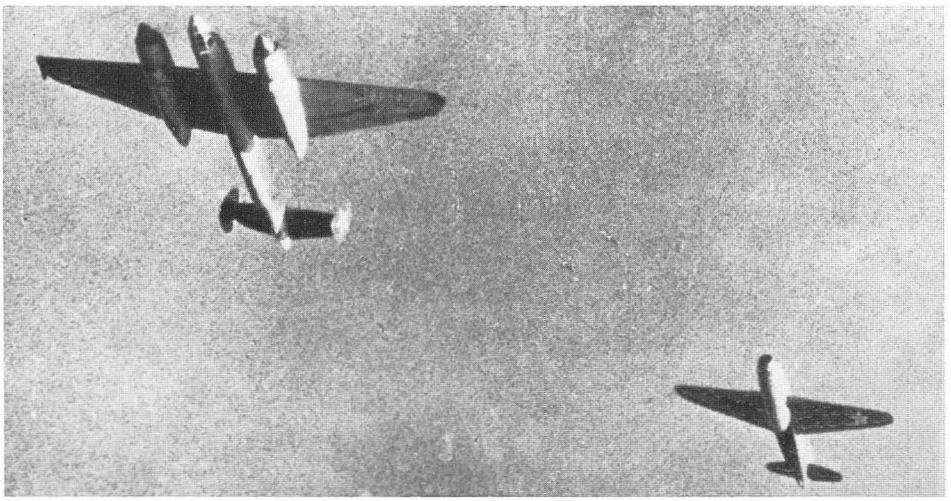
Above: The Yak17-RD10 development aircraft.

Above; Another view of the same aircraft. The redesigned landing gear is well illustrated by these views, as is the new cockpit canopy.

The Yak17-RD10 runs up its engine on the ground. Note that the engine cowlings have been removed.



Above: Yak-15 '47 Yellow' was used as a testbed for the wing-to-wing in-flight refuelling system. The refuelling hose can just be seen beneath the tail.



The Yak-15 formates with the Tu-2 'tanker' during a simulated in-flight refuelling.

fighter with a Jumo 004 (RD) engine based on a single-seat fighter currently in production and submit it for State acceptance trials by 1st November 1946;

2. Two-seat conversion and proficiency trainers shall have the same field performance as the respective single-seat combat aircraft. Both cockpits shall be fully equipped so as to permit flying the aircraft. Trainer aircraft may have a reduced weapons fit and, if necessary, a lower top speed.'

Pursuant to this order OKB-115 started developing a two-seat trainer derivative of the Yak-15. Initially it was known as the **Yak-Jumo *vyvoznoy*** (this adjective was the Soviet term for familiarisation and conversion trainers used at the time); later this appellation gave way to such designations as the **Yak-15V** (*vyvoz**noy***) and **Yak-15UT** (*oo**cheb**-no-treni**rov**ochnyy* – training, used attributively). Eventually, however, the trainer was officially designated **Yak-21** (some documents, though, call it **Yak-21V**). The trainer differed from the Yak-15 primarily in having a redesigned forward fuselage. The armament was deleted and a second cockpit for the trainee was provided where the cannon(s) had been; both cockpits were enclosed by a common sideways-opening canopy. The instrumentation and location of controls in both cockpits was similar to that of the single-seat Yak-15.

Construction of the prototype was undertaken by plant No. 31 in Tbilisi in the autumn of 1946. Since the Council of Ministers and MAP demanded that a dual-control fighter trainer be submitted for State acceptance trials by 1st November, this machine, as noted earlier, was the first to be laid down in the initial batch of single-seat Yak-15s. Additionally, to meet the demands of the Council of Ministers and MAP, the Tbilisi plant was to complete 25 dual-control machines by the end of April 1947. For various reasons, however, the entire production and test schedule went down the drain. Serialled 101 Yellow and bearing a yellow 'B' on the rudder (the Cyrillic letter 'V', which probably stood for *vyvoznoy*), the Yak-21 prototype commenced manufacturer's flight tests as late as 5th April 1947 instead of the autumn of 1946, as originally planned. The maiden flight was performed by test pilot P. U. Fokin.

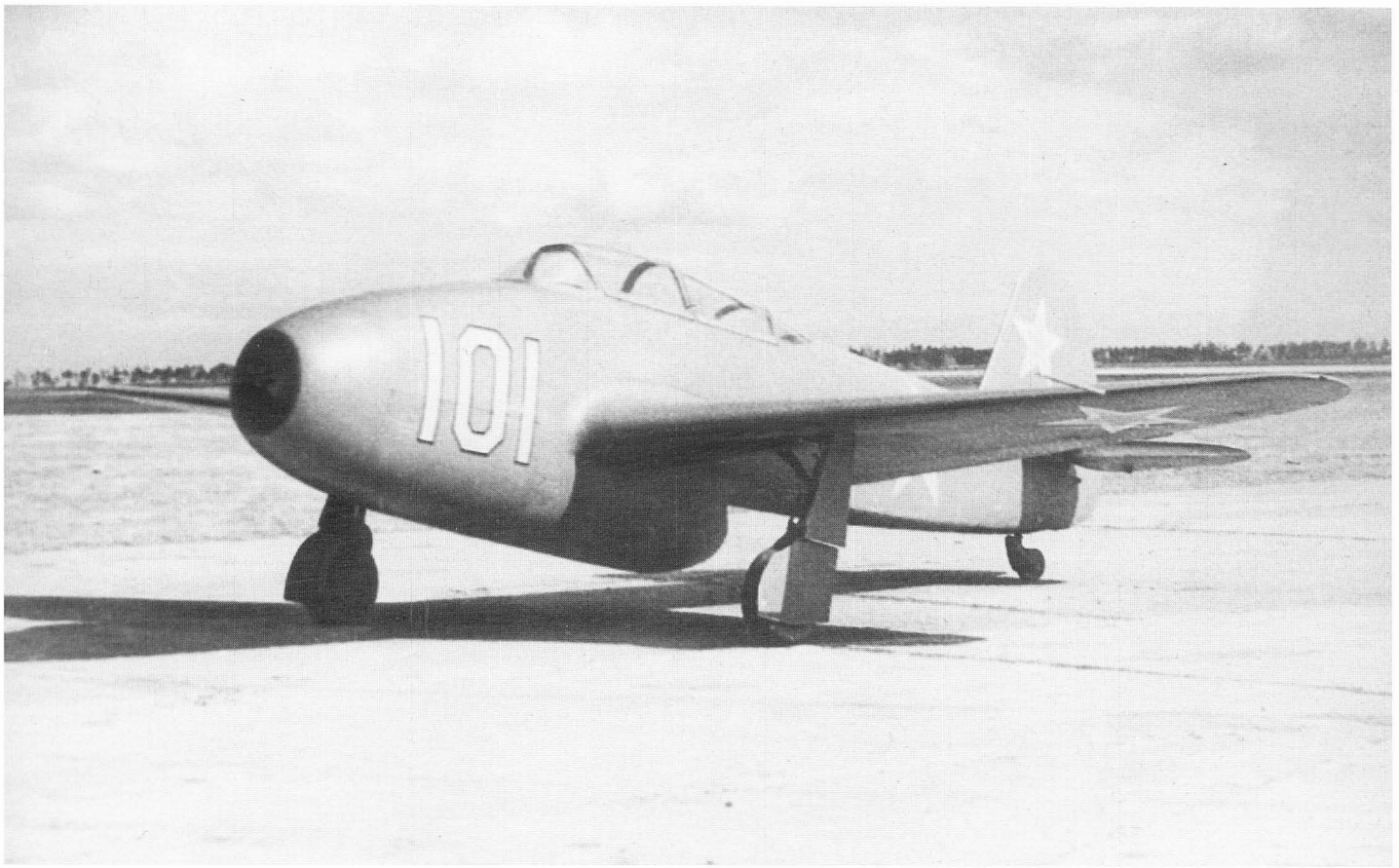
The machine flew well; nevertheless, in the course of the tests it became clear that a more promising dual-control version of the *Feather* (the Yak-21T, described below), which had been developed by then, would have better performance. Hence all further work on the 'taildragger' trainer was suspended. It is not known whether the performance characteristics of the aircraft were determined, but according to OKB-115's work plan for 1947 the Yak-21 with the tailwheel undercarriage was to possess the following performance: top speed at sea level, 770 km/h (416.21 kts); speed at altitude, 800 km/h (432.43 kts); service ceiling, 10,000 m (32,808 ft), climb time to 5,000 m (16,404 ft), 4.3 minutes; take-off run, 350 m (1,148 ft) and landing run, 400 m (1,312 ft).

As noted earlier, the Yak-15 had such serious shortcomings as inadequate range (only 510 km/316 miles) and an unsuitable undercarriage design. Back in May 1947 the protocol of the State acceptance trials stated that it was *'advisable [...] to develop the Yak-15 into a dual-control trainer with a tricycle landing gear'*. Therefore, almost concurrently with the development of the single-seat Yak17-RD10 and the two-seat Yak-21 the Yakovlev OKB set about developing a new version of the RD-10-powered single-seat fighter and its two-seat trainer variant, taking due regard to the new, more stringent requirements concerning stability, controllability and cockpit visibility of trainer aircraft, as well as to the requirement for a tricycle undercarriage. The single-seat fighter was designated **Yak-15U** (*u**looch**shennyy* – improved; in official documents it was referred to as the 'Yak15U-RD-10 with a tricycle undercarriage and drop tanks'), while the trainer version was designated **UTI Yak17-RD10** or **Yak-21T** (for ***tryokh**-ko**lyos**noye shas**see*** – tricycle landing gear).

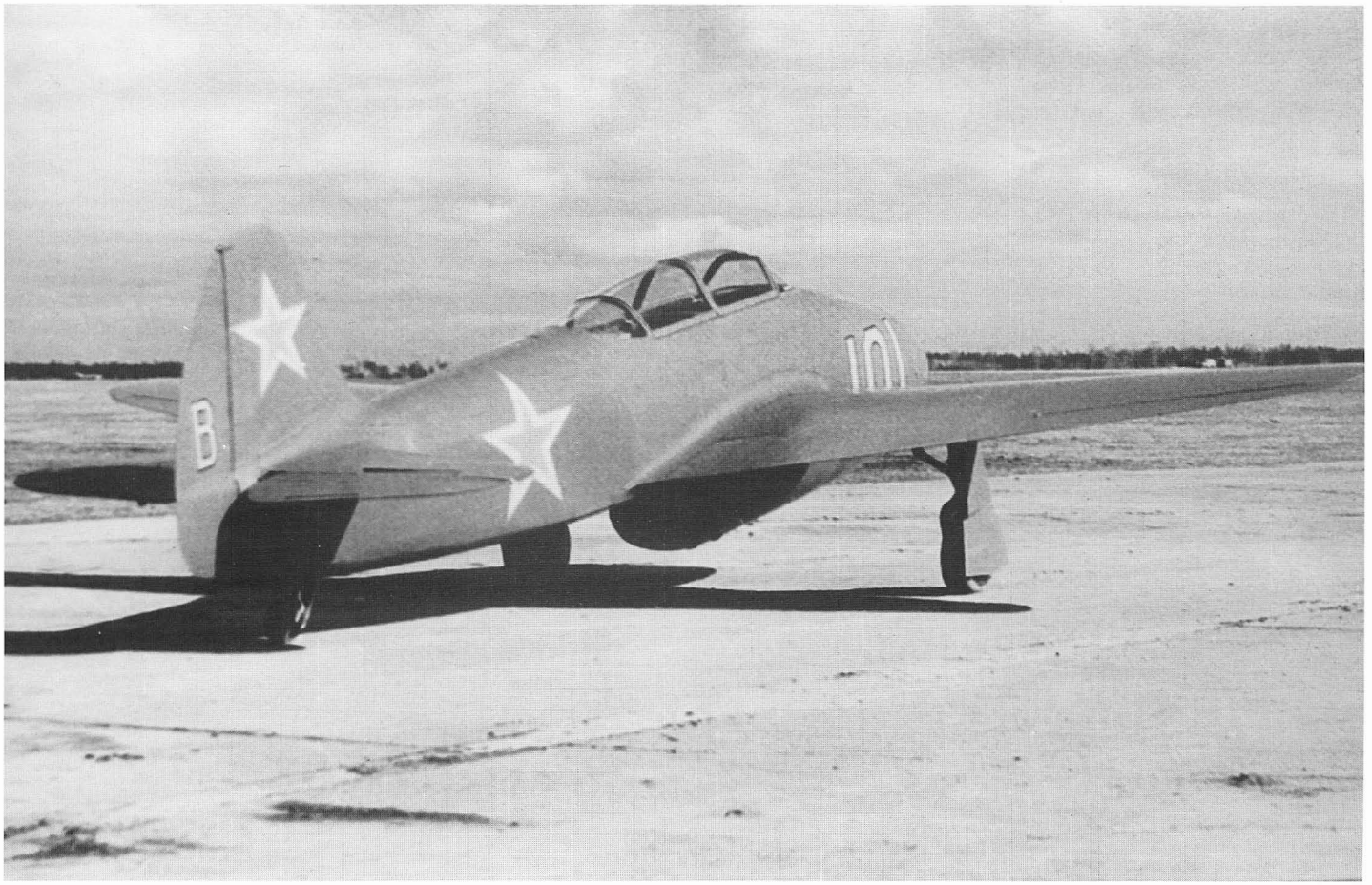
Like the baseline Yak-15, these aircraft featured a pod-and-boom layout. This time, however, the designers made use of the new nosewheel undercarriage facilitating take-off and landing; this necessitated some changes to the inboard portions of the wings and the forward fuselage structure. An auxiliary spar and additional ribs were introduced in the forward parts of the wings where the mainwheel wells were located; this not only enhanced the wing skin stiffness but also made it possible to place fuel tanks in the wings. The wing tanks were separated from the mainwheel wells by a curved spar; for maintenance they could be accessed via a detachable stressed cover plate on the underside of the wings.

The nose gear unit was semi-retractable; it pivoted aft to lie flat against the fuselage undersurface and was covered by a sizeable fairing. The wheel size was changed, too: the mainwheels now measured 570 x 140 mm (22.23 x 5.46 in), the nose unit had a 400 x 150 mm (15.6 x 5.85 in) wheel. The cockpit of the Yak15U-RD10 was increased in length and height to improve the pilot's posture, but the teardrop-shaped canopy of the standard Yak-15 was retained.

To increase range, drop tanks could be suspended under the wingtips which had to

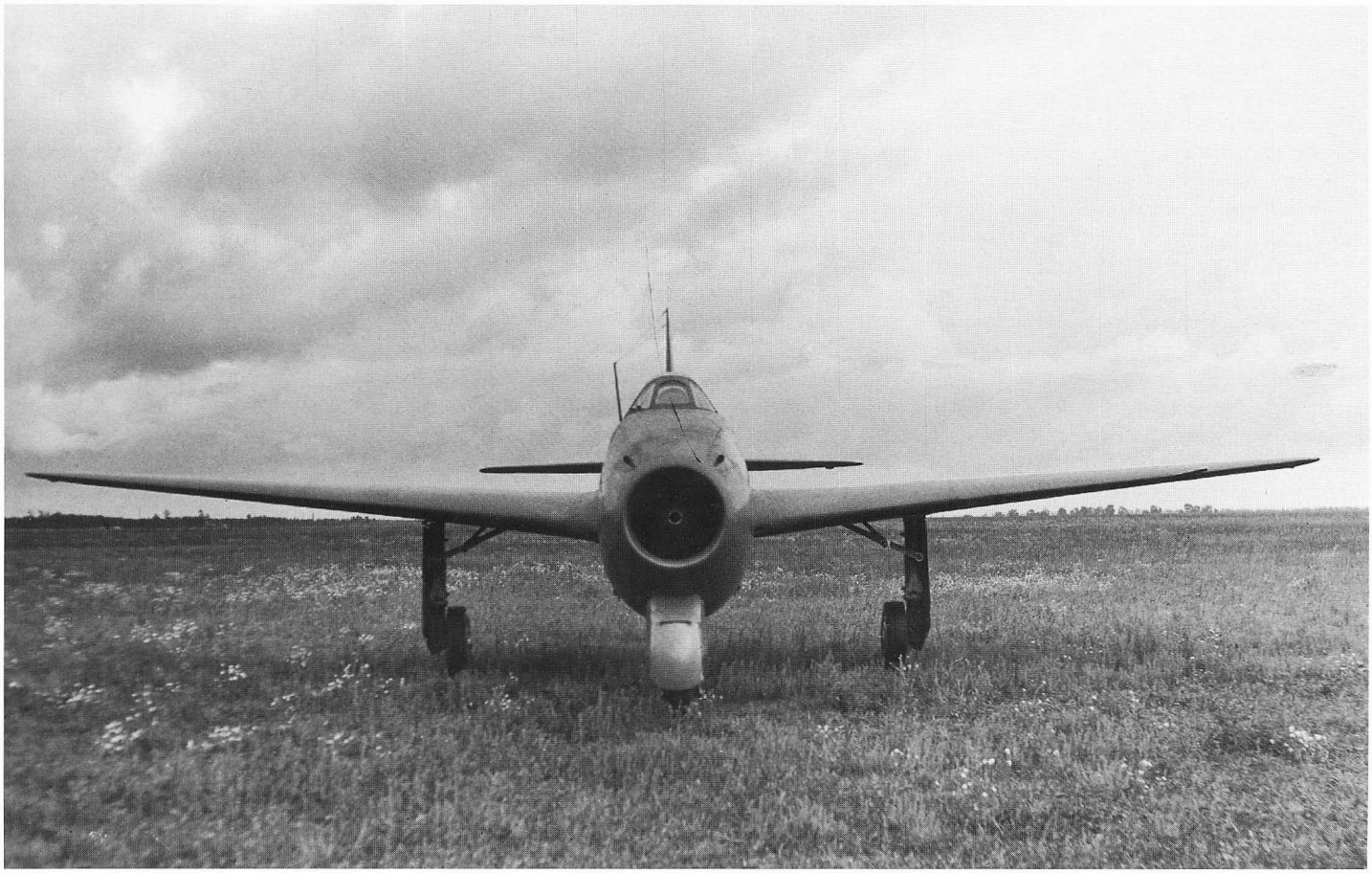


Above and below: 101 Yellow, the sole prototype of the Yak-21 conversion trainer derivative of the Yak-15. The Cyrillic letter V on the rudder probably stood for *vyvoznoy*, signifying the aircraft's role.



Above and below: The tricycle-gear Yak15U-RD10 was the prototype of the Yak-17. The serial looks very dark in these views but it is actually yellow, not red.

Above and below: Three-quarters rear view and head-on view of the same aircraft. Note the enlarged and recontoured vertical tail.



The Yak15U-RD10 prototype with drop tanks attached at GK NII VVS during State acceptance trials.

be suitably modified; in all, the drop tanks held up to 331 litres (72.8 Imp. gal.) of kerosene. On the UTI Yak17-RD10 (Yak-21T) the common canopy enclosing the cockpits had two separate sliding hoods; it dispensed with the moulded windscreen which was believed to distort the view.

To improve stability and handling of the new machines, the designers made some alterations to the shape of the horizontal and vertical tail. The fin was increased in height and the rudder's chord was reduced. The area of the horizontal tail was also increased by 0.1 m^2 (1.07 sq. ft) and its shape was altered, resulting in a more angular fin top; accordingly the aerodynamic compensation of the elevators was reduced to 19%. A certain revision of the size of the tail surfaces necessitated the addition of a spring and a bellcrank in the control system which increased the gearing ratio from the control stick to the elevators by 20%.

The avionics and equipment suite was somewhat simplified as compared to the combat version (the trainer featured an RSI-6 radio, an RPKO-10M DF, a GSK-1500 generator, a 12-A-10 DC battery and KP-14 breathing apparatuses with two oxygen bottles holding 2 litres (0.44 Imp. gal.) each) One thing the single-seater did not have, however, was the SPU-2M intercom. The fuel system of the UTI Yak17-RD10 (Yak-21T) was designed so as to enable the aircraft to perform aerobatic manoeuvres in inverted flight. The rest of the design was identical to that of the combat Yak-15U.

The Yak-21T prototype was manufactured by plant No. 464, making use of parts and assemblies of a production Yak-15 delivered from Tbilisi. This was the first jet aircraft produced by that factory, hence the machine received c/n 01464 (and the serial 22 Yellow). It took to the air in May 1947; in the subsequent two weeks it passed manufacturer's flight tests which were conducted by OKB-115 test pilot G. S. Klimooshkin and leading engineer N. I. Leonov. In the same month the new sparka was transferred to GK NII VVS for State acceptance trials which lasted from 31st May to 10th August (though the trials protocol was approved as early as 4th August).

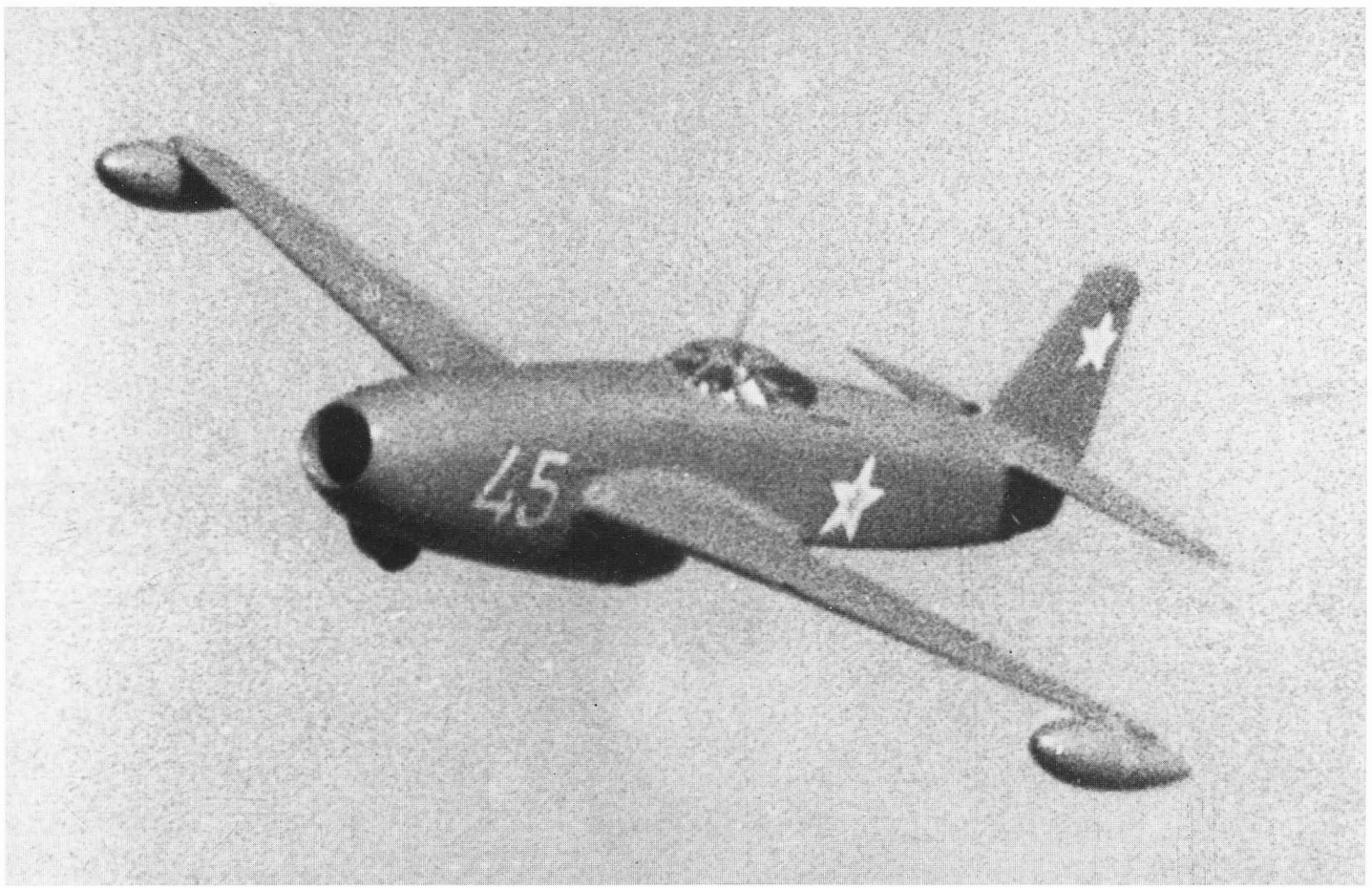
It turned out that the new trainer did not meet the Air Force's requirements on many counts. The top speed fell short of the expectations, the range was little more than half of the required figure; besides, the 10-minute limit imposed on continuous engine operation at maximum thrust rating made it possible to climb at the maximum rate only up to 8,000 m (26,246 ft). Also, the possibility of flying at high altitude was restricted by the insufficient fuel amount. The instructor could not start the engine, operate the undercarriage and flaps, nor could he maintain radio communication. Contrary to official requirements, the machine could not perform manoeuvres with negative G loads.

Still, the military testers also noted the trainer had its virtues. It could fly stably at high angles of attack; the trainer's strength margin enabled it to pull 8 Gs when performing aerobatics, and spin recovery was virtually instantaneous. Bearing in mind the absence of a two-seat jet trainer in the Air Force, the State commission found it possible to recommend the UTI Yak17-RD10 for series production. Since the trainer was passing the tests with no armament installed (such were the initial requirements), the concluding part of the test protocol suggested that *'...one NS-23 cannon and an S-13 gun camera be installed on production aircraft'*.

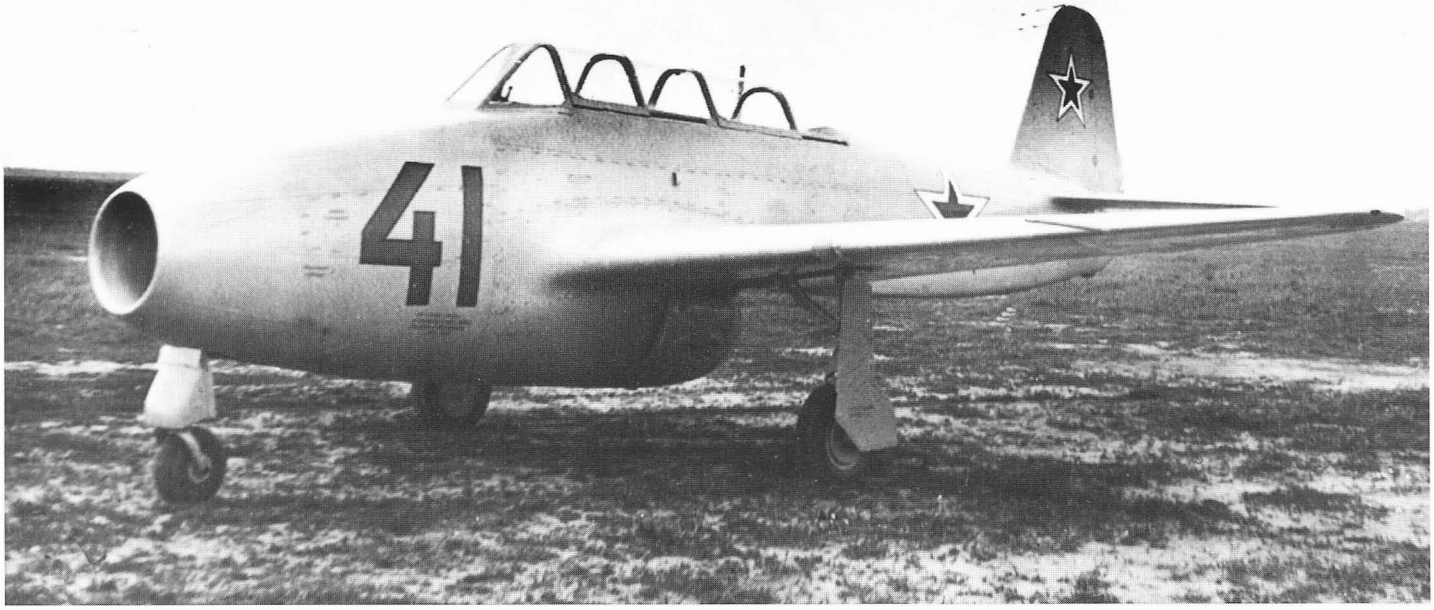
The results of the State acceptance trials were approved by the Council of Ministers in its directive No. 3284-1071 dated 17th September 1947; the directive called for the series production of the trainer to be launched at plant No. 31 under the service designation **Yak-17UTI.**

Checkout tests of a production Yak-17UTI (still lacking armament) were completed in the spring of 1948. They revealed a certain deterioration of the aircraft's performance (possibly caused by an increase in the all-up weight, including the fuel load). Nevertheless, thanks to its ease of handling and good per-

Above and below: Two air-to-air shots of the Yak15U-RD10 prototype; note the retracted position of the nose gear unit.

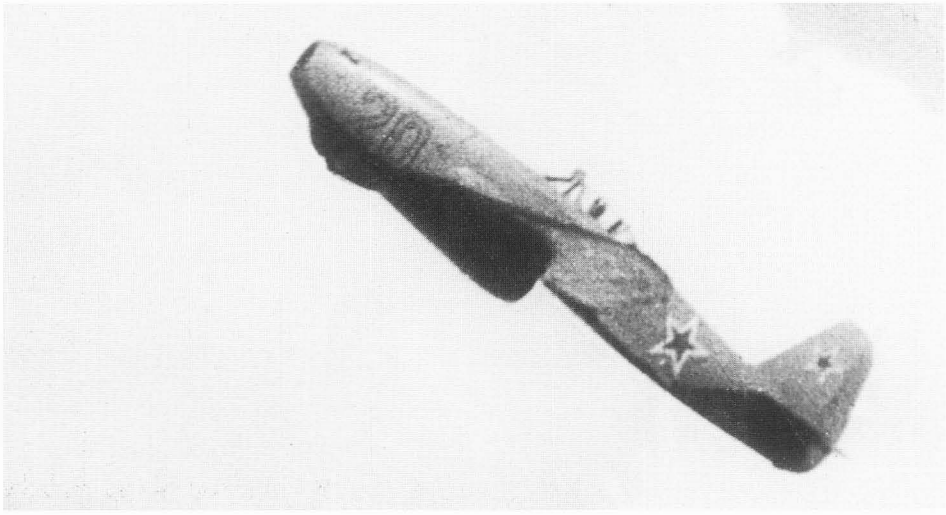


Above and below: 22 Yellow, the UTI Yak17-RD10 (Yak-21T) trainer prototype.

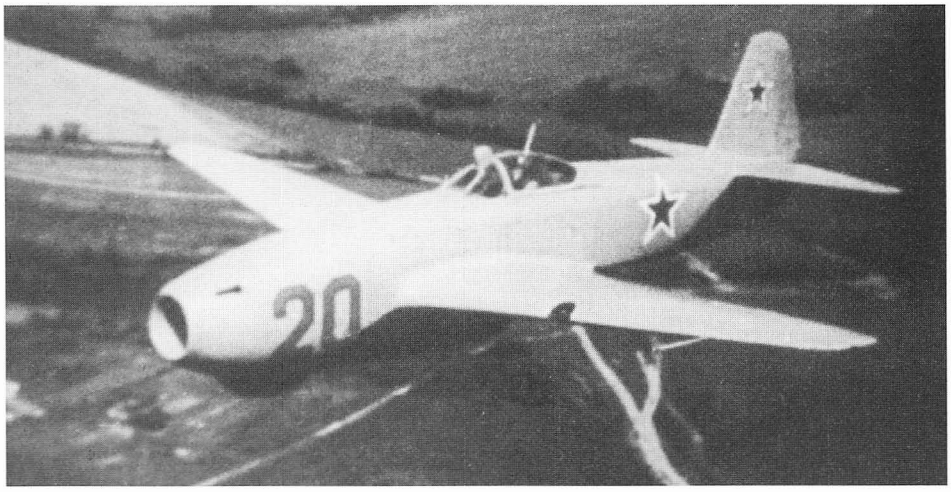


Above: A production Yak-17 serialled 41 Red seen during flight tests.

The UTI Yak17-RD10 (Yak-21T) prototype in flight.



Above and below: Two stills from a ciné film showing a production Yak-17 serialled 20 Yellow in flight.



formance the production jet trainer quickly won recognition among the pilots of the Soviet Air Force's fighter regiments. It played an important role in helping pilots master jet aircraft en masse. A few shortcomings were revealed in squadron service, notably the lack of an artificial horizon (which hampered the use of the machine in bad weather) and the absence of a step for boarding the aircraft.

The first prototype of the single-seat Yak15U-RD10 with a tricycle undercarriage (45 Yellow) was completed by plant No. 464 in the summer of 1947, a while later than the Yak-21T; this was done by converting a stock production Yak-15. The first flight took place in June, and manufacturer's tests conducted by leading engineer V. I. Yemel'yanov and test pilot G. S. Klimooshkin were completed on 10th August (the test protocol was endorsed on 23rd August), whereupon the machine was transferred to GK NII VVS. On 3rd August 1947, when the manufacturer's tests were drawing to a close, the aircraft took part in the annual Tushino flypast where it was flown by Klimooshkin.

State acceptance trials of the Yak15U-RD10 prototype began at GK NII VVS on 27th August 1947, ending on 15th November. The aircraft was tested with the armament installed, complete with an ASP-1 gunsight and a PAU-22 gun camera housed in the starboard outer wing panel. The normal all-up weight was 2,890 kg (6,371 lb), including 90 kg (198 lb) for the pilot, 555 kg (1,223 lb) of fuel, 10 kg (22 lb) of oil, 11 kg (24.25 lb) of start-up petrol, 74 kg (163 lb) for the two NS-23 cannons, – 46 kg (101 lb) of ammunition and 25 kg (55 lb) of detachable equipment; with drop tanks it amounted to 3,240 kg (7,142 lb). The trials were conducted by GK NII VVS leading engineer-cum-test pilot Gheorgiy A. Sedov, project test pilot Pyotr M. Stefanovskiy; the Yak15U-RD10 was also flown by A. G. Kochetkov, A. G. Proshakov, A. P. Sooproon, Yuriy A. Antipov, L. M. Koovshinov, V. G. Ivanov and V. I. Khomiakov.

The testers noted that in 'clean' condition the fuel amount available for level flight to a range of 395 km (245 miles) at 1,000 m (3,280 ft) and 407 km/h (220.0 kts) was 349 kg (769 lb), or 410 litres (90.2 Imp. gal.). With drop tanks, available fuel to cover a distance of 717 km (446 miles) at 8,000 m (26,246 ft) and 502 km/h (271.35 kts) was 693 kg (1,528 lb) or 815 litres (179.3 Imp. gal.); the rest of the fuel was used for a trial engine run on the ground, for gaining altitude and for descent and landing approach. Two unscheduled engine changes had to be made in the process of the State acceptance trials.

The protocol on the results of the trials said that, as far as piloting techniques, stability and controllability were concerned, the Yak-15U was virtually identical to the modified Yak-15 c/n 31002 which had been tested at GK NII VVS a while earlier. The landing procedure, however, was easier. During flights in turbulent conditions with the wingtip tanks in place the aircraft tended to yaw, this tendency being especially pronounced during turns. When put into a spin, the fighter transitioned to a smooth steep spiral and, in the event of a stall, recovered from the spin without delay. True enough, the State commission made quite a few critical remarks about the fighter; nevertheless, the concluding part of the Protocol on the results of the State acceptance trials ran as follows:

'1. The aircraft has passed State acceptance trials satisfactorily.

2. In its performance and armament it is superior to the production Yak-15 and can be introduced into Air Force service.'

After some modifications effected in the winter, the Yak-15U passed a new round of State acceptance tests in March 1948 and was once more recommended for service introduction.

The new version of the single-seat fighter was cleared for production at aircraft plant No. 31 in Tbilisi by directive No. 878-280s issued by the Council of Ministers on 20th March 1948; simultaneously, the aircraft received the service designation **Yak-17**.

A total of 430 aircraft (single-seat Yak-17s and two-seat Yak-17UTIs) was produced, of which 279 were manufactured in 1948. Production of the 'seventeen' went on until 1949. In the same year an aerobatic team flying nine Yak-17s and led by Lt. Col. N. Shool'zhenko put on an aerobatics display at the traditional Tushino air show.

Both versions were on strength with the Air Force and the Air Defence Command (PVO – ***Pro****tivovoz****doosh****naya obo****rona***) of the Soviet Union; besides, they were supplied to three 'friendly nations' – Poland, Bulgaria, Czechoslovakia and China. Somewhat surprisingly, the Yak-17 received the same NATO code name as its precursor – *Feather*.

Production machines differed from the prototype in some respects. Thus, the horizontal tail span was increased from 3.25 m (10 ft 7.95 in.) to 3.6 m (11 ft 9.73 in.); accordingly, its area rose from 2.83 to 2.916 m² (30.43 to 31.35 sq. ft). Conversely, the vertical tail area was reduced from 1.86 to 1.813 m² (20.0 to 19.49 sq. ft). The original NS-23 can-

	Yak15U-RD10	Yak15U-RD10 (prototype)	Yak15U-RD10 (prototype)	UTI Yak17-RD10 (prototype)	UTI Yak17-RD10 (prototype)	Yak-17UTI (production)
	OKB estimates (April 1947)	**Manufacturer's flight tests**	**State accept-ance trials**	**Manufacturer's flight tests**	**State accept-ance trials**	**Checkout trials**
Powerplant	RD-10	RD-10	RD-10	RD-10	RD-10	RD-10
Thrust, kgp (lb st)	900 (1,984)	900 (1,984)	900 (1,984)	900 (1,984)	900 (1,984)	900 (1,984)
Length overall	8.78 m (28 ft 9.67 in.)	8.78 m (28 ft 9.67 in.)	8.78 m (28 ft 9.67 in.)	8.7 m (28 ft 2.2 in.)	8.7 m (28 ft 2.2 in.)	8.7 m (28 ft 2.2 in.)
Wing span	9.2 m (30 ft 2.2 in.)	9.2 m (30 ft 2.2 in.)	9.2 m (30 ft 2.2 in.)	9.2 m (30 ft 2.2 in.)	9.2 m (30 ft 2.2 in.)	9.2 m (30 ft 2.2 in.)
Wing area, m^2 (sq. ft)	14.85 (159.67)	14.85 (159.67)	14.85 (159.67)	14.85 (159.67)	14.85 (159.67)	14.85 (159.67)
Empty weight (no drop tanks), kg (lb)	2,200 (4,850)	2,200 (4,850)	2,081 (4,587)	2,070 (4,563)	2,094 (4,616)	2,148 (4,735)
Take-off weight, kg (lb):						
normal	2,932 (6,464)	2,932 (6,464)	2,890 (6,371)	2,720 (5,996)	2,806 (6,186)	2,906 (6,406)
maximum (with drop tanks)	3,302 (7,279)	3,282 (7,235)	3,240 (7,142)	n.a.	n.a.	n.a.
Fuel load, kg (lb):						
normal	570 (1,256)	570 (1,256)	553 (1,219)	450 (992)	477 (1,051)	518 (1,142)
maximum (with drop tanks)	900 (1,984)	n.a.	884 (1,948)	n.a.	n.a.	n.a.
Top speed, km/h (kts):						
at sea level	700 (378.37) [1]	n.a.	702 (379.45)	770 (416.21) [3]	696 (376.21)	702 (379.45)
at 3,700 m (12,139 ft)	-	n.a.	n.a.	n.a.	n.a.	724 (391.35)
at 4,250 m (13,943 ft)	-	n.a.	751 (405.94)	n.a.	728 (393.51)	n.a.
at 5,000 m (16,404 ft)	764 (412.97)	n.a.	748 (404.32)	800 (432.43) [3]	726 (392.43)	719 (388.64)
at 6,000 m (19,685 ft)	-	785 (424.32)	n.a.	n.a.	n.a.	n.a.
Landing speed, km/h (kts)	160 (86.48)	n.a.	142/160 (76.75/86.48) [1]	150 (81.0)	162 (87.56)	n.a.
Rate of climb, m/sec (ft/min):						
at sea level	22.0 (4,329)	n.a.	17.6/15.2 [1] (3,463/2,991)	n.a.	20.8 (4,093)	18.4 (3,621)
at 5,000 m (16,404 ft)	-	n.a.	11.0/9.0 [1] (2,164/1,771)	n.a.	12.4	n.a.
at 8,000 m (26,246 ft)	-	n.a.	n.a.	n.a.	7.4	n.a.
at 10,000 m (32,808 ft)	-	n.a.	4.2 (826.56)	n.a.	n.a.	n.a.
Time to height, minutes:						
to 5,000 m	4.3	5.9	5.8/7.0 [1]	6.0	5.1	5.8
to 8,000 m	-	n.a.	n.a.	n.a.	10.2	n.a.
to 10,000 m	-	n.a.	17.5	n.a.	n.a.	n.a.
Service ceiling, m (ft)	12,000 (39,370)	n.a.	12,750 (41,830)	10,000 [3] (32,808)	12,100 (39,698)	n.a.
Range, km (miles):						
in 'clean' condition	350 (217)	n.a.	395 (245)	600 (372) [3]	370 (230)	330 (205)
with drop tanks	580 (360)	n.a.	717 (445)	n.a.	n.a.	n.a.
Endurance:						
in 'clean' condition	-	45 min	1 hr 1 min	n.a.	49 min	40 min
with drop tanks	-	1 hr 15 min	1 hr 34 min	n.a.	n.a.	n.a.
Take-off run ('clean'/with drop tanks), m (ft)	620 (2,034)	630/850 (2,066/2,788)	635/720 [1] (2,083/2,362)	590 (1,935)	575 (1,886)	640 (2,100)
Landing run, m (ft)	500 (1,640)	650 (2,132)	560/800 [2] (1,837/2,624)	800 (2,624)	695 (2,280)	700 (2,296)
Armament	2 x NS-23 w. 60 rpg	? ?	2 x NS-23 w. 105 rounds	n.a. n.a.	n.a. n.a.	n.a. n.a.

Notes:

1. With drop tanks

2. With a landing weight of 2,400/2,750 kg (5,291/6,062 lb)

3. As stated for the 'taildragger' Yak-21 in the prototype construction plan for 1947

Above and below: The Yak-17 preserved in the Central Russian Air Force Museum in Monino. Here it is seen in its original grey colour scheme.

nons gave way to the NS-23K version featuring a longer barrel, and the PAU-22 gun camera was replaced with the new S-13 (it was mounted on top of the cockpit windshield).

Yak-17 c/n 311177 (ie, plant No. 31, Batch 11, 77th aircraft in the batch) and examples with c/ns 311205 through 3112118 were fitted with ASP-3M optical gunsights. The USB-1 ammunition counted was introduced from c/n 311222 onwards, enabling the pilot not only to see how many rounds remained but also to fire short bursts. Late-production machines were powered by RD-10A engines having a TBO increased to 50 flying hours.

The dimensions and performance characteristics of different versions of the Yak-17, based on the results of calculations, manufacturer's flight tests and State acceptance trials are compared in the table on page 73.

Re-equipment with the Yak-17 turned out to be a lengthy process, and the time at which Soviet fighter regiments took delivery of the new machines varies widely. Thus, for instance, the 472nd IAP (Fighter Air Regiment) which was based at Kursk-Vostochnyy (= Kursk-East) airfield for a long time, re-equipped with Yak-17s in the spring of 1950 immediately after being established; as early as 22nd July it was pronounced fully combat-ready, whereupon it started fulfilling combat duty in the PVO system.

The limited amount of fuel would be used up in just 25 to 28 minutes, which meant Yak-17 pilots could perform only short flights (Yak-17UTI trainer operations were thus restricted to the area adjoining the airbase). Besides, starting the engine on the ground was rather complicated and involved several operations: cranking up the two-stroke starter, accelerating the turbine, starting the engine proper on the easily combustible petrol, switching over to kerosene feed etc. On the other hand, the Yak-17 was easy and pleasant to fly. A low level of noise in the cockpit, good forward visibility, a short take-off run and a relatively high flight speed were the jet fighter's strong points in comparison with piston-engined machines.

Turbojet engines have a few quirks, which made it necessary to tackle such problems as turbine blade burnout and engine surge. This required the pilot to acquire new habits, such as maintaining the permissible throttle movement speed (moving the throttle too sharply would cause the engine to surge). In contrast to piston engines possessing good acceleration, a turbojet engine gains rpm slowly. Increasing the engine thrust resulted in a quicker build-up of the forward speed. However, aerobatic manoeuvres on a jet fighter could not be performed as briskly as on piston-engined aircraft.

Flight incidents and minor accidents were not uncommon. In 1948 Hero of the Soviet Union G. A. Bayevskiy mastered flying the MiG-9 and Yak-17UTI jets, transitioning to the combat Yak-17 in the summer of the following year. In one of the flights a landing gear wheel disintegrated, and the pilot took the decision to try a belly landing on the turf next to the runway. During the landing approach the aircraft caught fire, and as it touched down the fire reached the cockpit. In a display of courage, the pilot opened the canopy and jumped out of the moving fighter; he was rewarded for this feat by the Air Force command.

Jet-powered Yaks did not enjoy a long service career with the Soviet Air Force. Thus, for example, as early as December 1950, a mere six months after the Yak-17 achieved initial operational capability, the 472nd IAP started converting to the MiG-15, the most advanced Soviet fighter at the time.

One example of the single-seat Yak-17 with the tactical code 02 Red survives in Russia; it has been on display in the Central Russian Air Force Museum in Monino for many years in good condition. Unfortunately by 1998 it had been repainted in a non-authentic green colour scheme.

As noted earlier, the Yak-17UTI was supplied to Bulgaria, China, Czechoslovakia and Poland.

Bulgaria: The Bulgarian Air Force (BVVS – *Bolgarski Voyenno Vozdooshni Seeli*) operated the *Feather* in both fighter and trainer versions. Unfortunately no details are known.

Czechoslovakia: The Czechoslovak Air Force (CzAF or CVL – *Ceskoslovenské Vojenské Létectvo*) took delivery of a small number of Yak-17s (possibly ex-VVS aircraft). One of them is now on display at Kbely.

China: The year of 1950 saw the beginning of large-scale deliveries of combat aircraft to China, together with the deployment of Soviet Air Force units to that country where a civil war had erupted. Soviet instructors trained the flight and ground crews of the nascent People's Liberation Army Air Force (PLAAF, or *Chung-kuo Shen Min Taie-Fang-Tsun Pu-tai*); this included conversion to jet hardware, for which purpose MiG-9 fighters and Yak-17UTI trainers were sent to China. In particular, the Soviet Air Force's 29th GvIAP (*gvar**dey**skiy istre**bit**el'nyy **a**via**polk*** – Guards fighter regiment) of the 324th IAD (*istre**bit**el'naya **a**viadi**vee**ziya* – fighter division) was engaged in training Chinese pilots on the Yakovlev jets. By piloting the two-seat Yaks Chinese airmen got accustomed to the special take-off and landing techniques of aircraft with a nosewheel undercarriage (which was still a novel feature at the time).

Crates with dismantled Yak-17UTIs arrived at the airbase where the 29th GvIAP was stationed in the evening of 20th August. The unit's tech staff spent the whole of the following day assembling the trainers. On 22nd August the first reassembled aircraft performed a 12-minute check flight, whereupon seven Chinese pilots were taken for familiarisation flights in it within less than one hour. The Chinese pilots must have been quite experienced, since on the following day five of them made solo flights in the MiG-15 after performing just a few flights each on the Yaks.

One of the surviving Chinese Yak-17UTIs is now on display at the PLAAF Museum at Datangshan AB.

Poland: In late 1949 and early 1950 the Soviet and Polish governments considered the possibility of building the Yak-17 in Poland under licence. The aircraft factory in Mielec (pronounced ***Mel****ets*), a division of the WSK PZL concern (*Wytwórnia Sprzetu Komunikacyjnego – Panstwowe Zaklady Lotnicze*, Transport equipment manufacturer – State aircraft factories), even started gearing up for production; at WSK Mielec the fighter was known as the **G-1**, though this was probably just a product code. Eventually, however, plans to build the *Feather* were dropped due to the rapid development of jet fighter technology. Instead, the Polish aircraft industry started investigating the general issue of manufacturing aircraft of all-metal semi-monocoque design which were better suited to a greater variety of roles. Later, the aero-engine factory WSK Rzeszów (pronounced ***Zheh****shoow*) manufactured a batch of thirty RD-10A turbojets under licence; known in-house as the G-2, the engines were intended for the Jak-17W trainers, as the Yak-17UTI was designated by the Polish Air Force.

In July 1950 the command of the Polish Air Force (PWL – *Polskie Wojsko Lotnicze*) sent a group of four pilots to a Soviet Air Force/4th Air Army unit stationed in Poland for conversion training so that they could master jet fighters. The group included Lt. Col. Vasiliy Gashin, a Soviet military advisor to the PWL's top command, Lt. Col. Aleksandr Markov (another Soviet military advisor seconded to the Officers' Higher Flying School (WOSL – *Wyzsza Oficerska Szkola Lotnicza*) – popularly known as *Szkola Orlat* (Eaglets' School) – in Dęblin, Capt. Andrzej Rybacki of the Polish Air Force's 1. PLM 'Warszawa' (*pulk lotnictwa mysliwskiego* – fighter regiment) based at Minsk-Mazowiecki AB near the Polish capital and *porucznik* (Lieutenant) Kazimierz Tanana of the 2. PLM. The training was initially performed on Yak-17UTIs but the pilots soon transitioned to the single-seat combat version. Training proceeded quickly; in early August Rybacki and Tanana made their first solo flights, each logging six hours total time on jets by the time they completed the training course.

A pilot climbs into the front cockpit of Yak-17UTI '07 Yellow'.

Ground crews check the pilot's gear before a sortie.

The first three Yak-17s for the PWL arrived in Warsaw in July 1950. The fighters were delivered to Warsaw-Okecie (now the city's international airport) in crates and reassembled there; the first aircraft serialled 29 Red was reflown by Vasiliy Gashin. Later the fighter was demonstrated to the Polish Air Force top brass and the leaders of civil aviation and aircraft industry establishments at Warsaw-Okecie and Warsaw-Bemowo.

In August the first jet fighter bearing red and white *szachownicy* (checkerboards, as the Polish national insignia are called) was demonstrated in flight over Polish military airfields. The Yak-17 required special ground support equipment and therefore could not land at every airfield. On 20th August 1950 the Yak-17 was presented for the first time to the general public at Okecie during the Aviation Day festivities. A short while later the grey-green machine bearing the tactical number '29' and piloted by Lt. Col. Vasiliy Gashin made a low-level pass over the grandstands. This was the fourth item in the flying display programme; it was intended to demonstrate how fast a jet aircraft could go. At the end of the festivities Lt. Col. Gashin gave a spirited aerobatics display, performing consecutively a zoom climb, a loop, a dive, a barrel roll to starboard, a barrel roll to port, a double barrel roll to starboard, a wingover and a steep zoom climb showing to good advantage the aircraft's excellent rate of climb. At the show the fighter was flying without wingtip tanks.

A production Yak-17UTI serialled 19 Yellow about to taxi out for a training sortie.

The first public demonstration of a jet aircraft in Poland impressed the spectators very much and received much comment in the general and specialist press.

In early 1951 one more group of pilots took their initial jet training course on Yak-17UTIs in the Soviet Union and proceeded to conversion training on the combat Yak-23s. The pilots performed 15 flights each in the Yak-17UTI (in Polish documents it was referred to as **Jak-17W**), including two examination flights. Every flight lasted 10 to 15 minutes.

By mid-1951 the Polish Air Force already had several types of jet fighters in its inventory. The Yak-17s were assigned to fighter units where they were unofficially dubbed 'Agata'. During the Aviation Day festivities in 1951 the Yak-17Ws took part in flights together with the Yak-23s. In 1953 the Officers' Air Training School No. 5 named after Zwirka and Wigura (*Oficerska Szkola Lotnicza nr 5 im. Zwirki i Wigury*) set up in Radom in 1951 received Yak-17Ws which were used for conversion training to the Yak-23. These aircraft were used by the OSL-5 relatively briefly and were superseded by the UTI-MiG-15.

In 1957 two Yak-17Ws were transferred to the Aviation Institute (IL – *Instytut Lotnictwa*). The first of them, serialled 1 Red, landed on the Institute's airfield on 21st January; the other one (4 Red) followed on 4th March. Both machines were ferried by engineer Andrzej Ablamowicz, the first Polish civil pilot to master a jet aircraft. Yak-17W '4 Red' later received the civil registration SP-GLM. It was used for training the Institute's pilots who were expected in the near future to test the prototype of the locally designed PZL TS-11 Iskra (Spark) jet-powered advanced trainer. The aircraft was also flown for the purpose of determining performance characteristics (stability, controllability and endurance). The last flight of SP-GLM took place on 3rd February 1960. From 1963 onwards the aircraft was used primarily as a static exhibit at various airshows, and *szachownicy* were again applied to it in addition to the civil registration (!). In August 1964 the same machine (this time in full military colours and with the tactical number '02 Red') was shown at an aviation hardware display at Rakowice airfield in Kraków. At present this aircraft constitutes a unique exhibit of the Aerospace Museum (*Muzeum Lotnictwa i Astronautyki*) in Kraków. This is the sole surviving Yak-17 in Poland.

The first Soviet jet fighters (the MiG-9, Yak-15, Yak-17 and S. A. Lavochkin's aircraft 'aircraft 150', 'aircraft 152' and 'aircraft 156') were designed around captured German engines rated at only 800 to 900 kgp (1,764 to 1,984 lb st). Understandably, they were no match for American and especially British fighters powered by engines delivering nearly twice the thrust. To close this gap the Soviet leaders decided to resort temporarily to purchasing British turbojet engines – the 1,625-kgp (3,583-lb st) Rolls-Royce Nene I and the 2,270-kgp (5,005-lb st) Rolls-Royce Derwent V – until similarly-rated Soviet engines entered mass production. In accordance with a Council of Ministers directive dated 11th March 1947 several design bureaux were to rapidly develop new types of aircraft around these engines. In particular, OKB-115 was tasked with creating a tactical fighter powered by a Derwent V and featuring straight wings.

The choice of unswept wings may be tentatively explained as follows. Firstly, quite probably due regard was taken to the wishes of Aleksandr S. Yakovlev himself whose attitude towards swept wings was still cautious (keep in mind that Yakovlev enjoyed great authority both in MAP and in the Government, his opinions carried weight and he had no difficulty in securing the necessary decisions). Secondly, both the ministry and the Government obviously decided to play safe, in case the future Mikoyan and Lavochkin aircraft with swept wings proved to be a failure. Yet, no one questioned the assumption that only swept-wing aircraft could reach high speeds and crack the sound barrier.

Quite possibly A. S. Yakovlev fully realised that in the case of the Mikoyan and Lavochkin OKBs scoring a success his design bureau would lose its leading position as a 'fighter

maker' and would be relegated to a secondary role. Therefore he decided to work on two fighters in parallel; one would be developed in accordance with the Government directive and the other, a more agile aircraft, as a 'private venture'. The former of the two OKB-115 projects received the designation Yak-25 (this aircraft is described in the next chapter) while the other fighter was designated **Yak-23**. Interestingly, the work on the latter project remained a hush-hush affair for a long time; this may have been due partly to the security regulations enforced in those days.

The Yak-23 jet fighter developed 'beyond the call of duty' employed the pod-and-boom layout which had already been thoroughly studied by Yakovlev's design team; all the elements of the aerodynamic layout had been verified on the preceding models.

The fighter was of all-metal construction. The mid-set two-spar wings with TsAGI-type slotted flaps used a laminar airfoil section. The designers placed the engine in the forward fuselage, the nozzle being located under the centre fuselage as usual. The fuselage itself was a semi-monocoque structure featuring a maintenance break (the nose section was detachable for the purpose of installing the engine).

The tail unit had a cruciform layout, the fin and the stabilisers featuring a two-spar structure. The aircraft had a fully retractable tricycle undercarriage, the main units retracting inwards so that the mainwheels were stowed partially in the wings and partially in the fuselage; the nose unit retracted forward to lie in the air intake splitter. As had been the case with the OKB's previous products (the Yak-15 and Yak-17), the Yak-23's armament consisted of two 23-mm NR-23K cannons in the forward fuselage, except that these were accommodated beneath the engine instead of above it. Drop tanks could be carried under the wingtips.

The designers embarked on projecting the machine without even having seen the RR Derwent engine in actual hardware, having at their disposal only a drawing outlining its basic dimensions. Therefore, it says a lot for the design team that when the real engine eventually reached the OKB, its installation required almost no alterations to the prototype's airframe.

In accordance with the order of the Minister of Aircraft Industry 'On the preparation of aircraft for the 18th August 1947 flypast' Chief Designer and Director of plant No. 115 A. S. Yakovlev was instructed to *'...complete construction of the Yak-23 powered by the Derwent V turbojet by 15th June and initial flight testing of the aircraft by 30th July'*. As was his wont, Yakovlev complied with the prescribed time limits. Serialled 52 Yellow and bearing a yellow numeral '3' on the rudder, the first prototype (c/n 115001, ie, plant No. 115, 001st aircraft) was completed in June; a month later OKB-115 test pilot Mikhail I. Ivanov performed the fighter's maiden flight. The first prototype was powered by one of the genuine Derwent-V engines bought in the UK and rated at 1,625 kgp (3,583 lb st).

The manufacturer's tests conducted by leading engineer V. Shelepchikov and pilot M. I. Ivanov proceeded quickly (they were completed on 24th September 1947) and, in the opinion of the OKB, successfully. A top speed of 932 km/h (503.78 kts) was attained at sea level, and the maximum Mach number attained at high altitude was 0.845. The fighter possessed excellent handling qualities and easily performed all aerobatic manoeuvres. On the other hand, some performance parameters were not determined (even the airspeed indicator was not calibrated, which could lead to incorrect readings), so great was the hurry to submit the fighter for State acceptance trials.

On 3rd August, while the manufacturer's tests were still in progress, the Yak-23 prototype was demonstrated at the Tushino air display (flown by M. I. Ivanov).

On 22nd October the second prototype Yak-23 (c/n 115002) – confusingly, bearing the same serial '52 Yellow' but marked with a yellow '2' on the rudder – was submitted to GK NII VVS for State acceptance trials. (This elaborate deception was part of the OKB's security measures; see also next chapter.) The trials were conducted by project test pilot Gheorgiy A. Sedov, who had conducted the State acceptance trials of all Yak jets featuring the pod-and-boom layout, and pilots P. M. Stefanovskiy, A. G. Kochetkov, A. G. Proshakov, V. I. Khomiakov, I. M. Dziuba, L. M. Koovshinov and OKB test pilot V. I. Ivanov. In the course of the State acceptance trials which began on 11th November, the Yak-23 attained a maximum speed of 925 km/h (575 mph) at sea level and displayed an excellent rate of climb: the vertical speed at sea level (without drop tanks) was 41.4 m/sec (8,147 ft/min); time to 5,000 m (16,404 ft) was 2.3 minutes. Range at 5,000 m with wingtip tanks was 1,035 km (643 miles), and practical ceiling was 14,800 m (48,556 ft). The majority of the fighter's performance characteristics were determined at the normal all-up weight of 2,965 to 3,036 kg (6,536 to 6,693 lb) in 'clean' configuration and 3,306 to 3,389 kg (7,288 to 7,471 lb) with wingtip tanks. In 'clean' condition the fighter had a short take-off run of only 440 m (1,443 ft), the landing run being 540 m (1,771 ft).

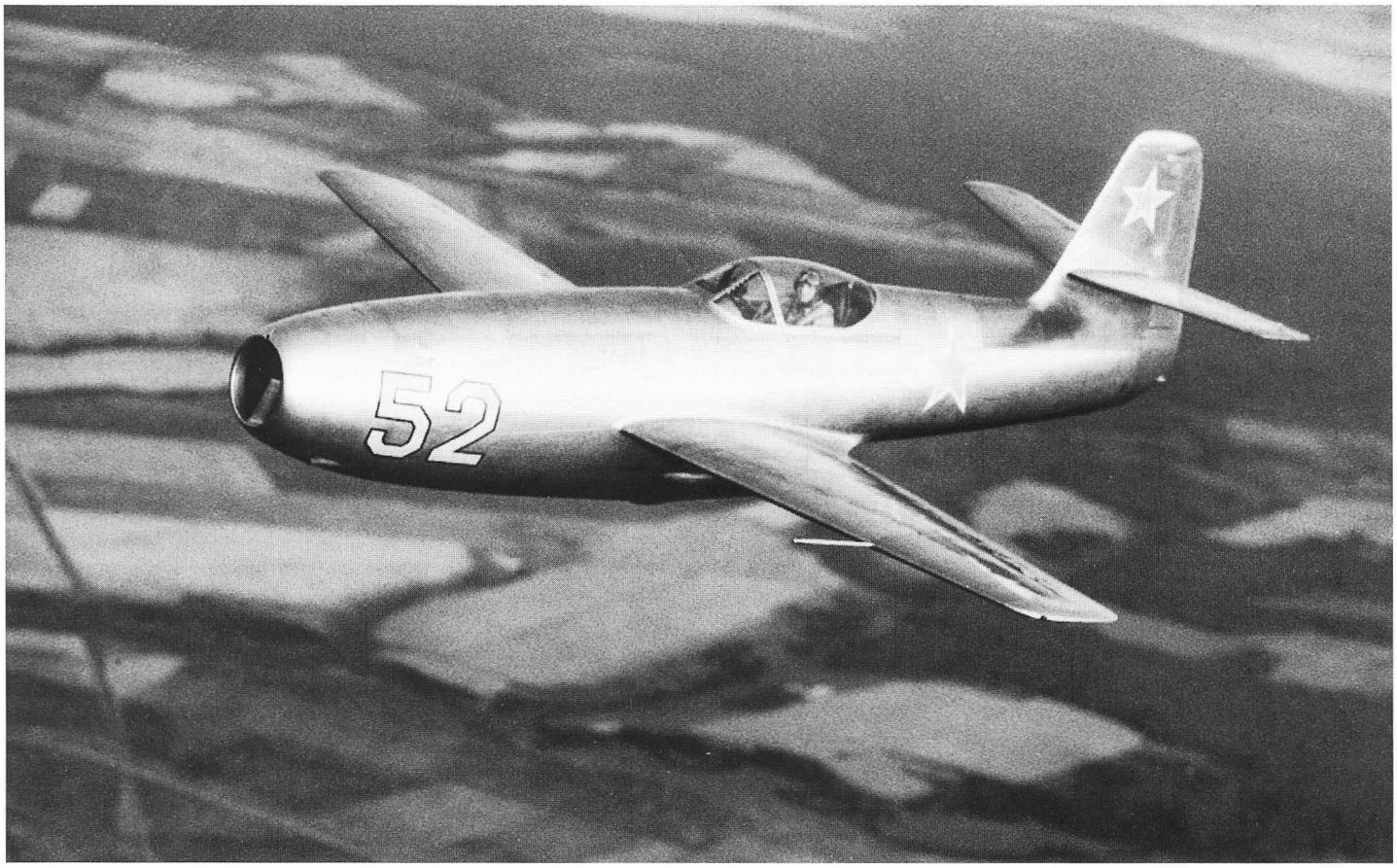
The test pilots came to the conclusion that the Yak-23 could be used quite successfully against enemy fighters. The State acceptance trials protocol noted that the Yak-23 was both faster than the indigenous MiG-9 and Su-9 fighters (the first aircraft to have this designation; see Chapter Five) and possessed a much better rate of climb than either of these types. Being superior in basic performance characteristics to all existing Soviet jet fighters, the Yak-23 was second-best to the Su-9 only as far as the deceleration time in level flight was concerned.

Taking note of the Yak-23's undoubted merits, the pilots nevertheless placed their main emphasis the fighter's shortcomings in their reports. Regarding the slow deceleration, they rightly pointed out that the fighter's manoeuvrability characteristics are restricted by the absence of airbrakes. Other drawbacks noted included insufficient range of radio communication with the ground, excessive stick and rudder pedal forces and the unpressurised cockpit which, in the event of aerial combat at high altitude and with G loads exceeding 5 Gs, required great physical endurance on the part of the pilot (due to the insufficient amount of onboard oxygen). In the course of the State acceptance trials two sessions of mock combat were successfully conducted against the Tu-12 ('aircraft 77') bomber – the first jet bomber produced by Andrey N. Tupolev's OKB-156. The concluding part of the State acceptance trials protocol said that the fighter *'...can be introduced into service...'*.

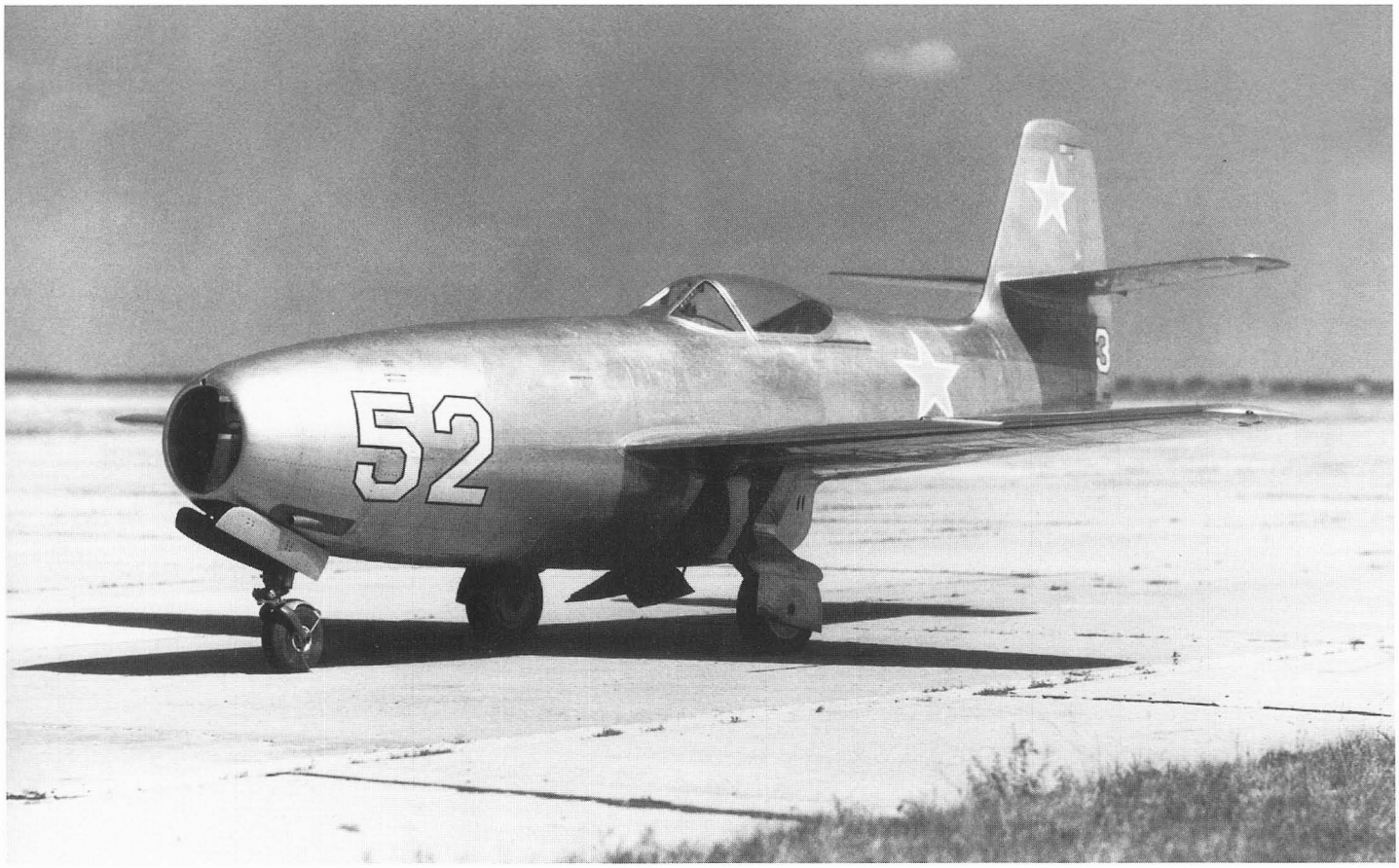
Notwithstanding the many merits of the Yak-23, the presence of numerous shortcomings and limitations delayed the final decision as to whether the aircraft should be put into production. This was possibly influenced by the fact that the first prototype Yak-25 entered initial flight tests in October 1947. As the reader remembers, this fighter had been created in accordance with the Council of Ministers directive and met most of the Air Force's requirements (it was fitted with a pressurised cockpit, and many of its performance characteristics were superior to those of the Yak-23).

The final decision on the expedience of launching production of the Yak-23 was delayed by a year. The prototypes of the MiG-15 (I-310) and La-15 ('aircraft 174') fighters completed their manufacturer's flight tests in 1948, demonstrating the undoubted advantages of swept-wing aircraft. Nevertheless, at the end of 1948 the Government took the decision to put the Yak-23 into series production. This was due to the fact that the MiG-15 featuring a more advanced layout and powered by the 2,270-kgp (5,005-lb st) RD-45 engine was still suffering from a number of teething troubles. Therefore, as a sort of insurance policy, it was decided that in parallel with the introduction of the MiG-15 into mass production, series manufacture would be started of the Yak-23 which was not expected to harbour any surprises.

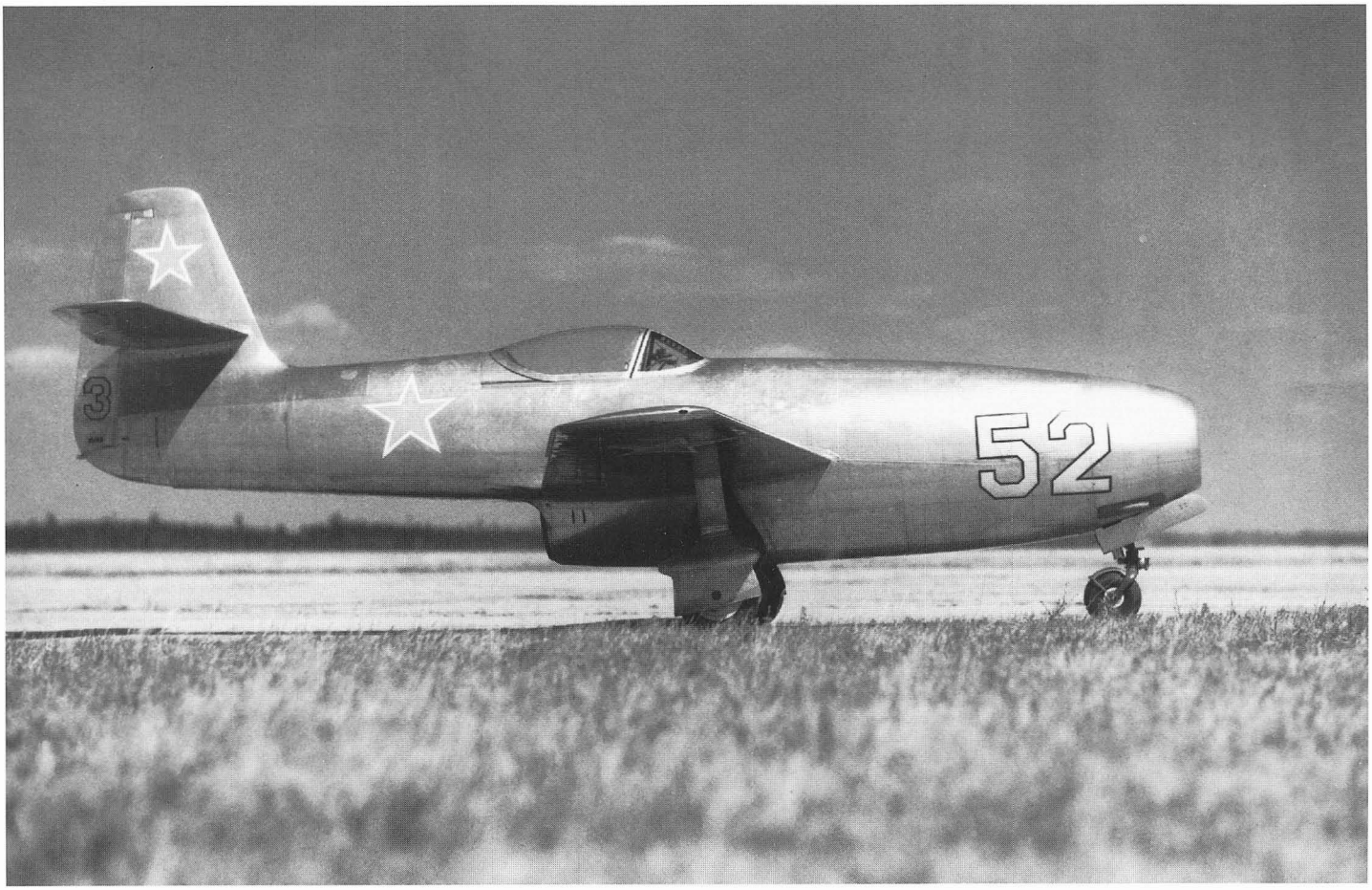
Above: 52 Yellow, the first prototype Yak-23, nearing completion in the assembly shop of MMZ No. 115.



An air-to-air shot of the first prototype Yak-23.



Above and below: Two views of the first prototype Yak-23 during manufacturer's flight tests. Note nosewheel mudguard.



Above and below: In an effort to confuse spies, the second prototype was also serialled 52 Yellow; however, the digit on the rudder was 2 instead of 3.

Above: A side view of the second prototype Yak-23.

This Yak-23 serialled 01 Red and equipped with drop tanks underwent checkout trials at GK NII VVS.

The dimensions and performance characteristics of the Yak-23 as recorded during the State acceptance trials of the second prototype (No. 2, as it was referred to in GK NII VVS documents) are presented in the following table.

Length overall	8.10 m (26 ft 6.89 in.)
Wing span	8.73 (28 ft 7.7 in.)
Wing area, m2 (sq. ft)	13.7 (147.31)
Empty weight, kg (lb)	1,902 (4,194)
All-up weight, kg (lb):	
normal	
(without wingtip tanks)	2,965-3,036 (6,536-6,693)
maximum	
(with wingtip tanks)	3,306-3,389 (7,288-7,471)
Fuel load, kg (lb):	
normal (without wingtip tanks)	790 (1,742)
maximum (with wingtip tanks)	1,109 (2,450)
Top speed, km/h (kts):	
at sea level	925 (500.0)
at 5,000 m (16,404 ft)	910 (491.89)
at 10,000 m (32,808 ft)	868 (469.19)
at 12,000 m (39,370 ft)	831 (449.19)
Landing speed, km/h (kts)	157 (84.86)
Time to height, minutes:	
to 5,000 m	2.3
to 10,000 m	6.2
Rate of climb, m/sec (ft/min)	
at sea level	41.4 (8,146)
at 5,000 m	30.4 (5,983)
at 10,000 m	19.2 3,779)
Range in 'clean' condition/	
with drop tanks, km (miles):	
at 5,000 m (16,404 ft)	580/785 (360/488)
at 7,000 m (22,965 ft)	760/1,035 (472/643)
at 10,000 m (32,808 ft)	1,080/1,475 (671/916)
Endurance in 'clean' condition/	
with drop tanks:	
at 1,000 m	1 hr 11 min/1 hr 34 min
at 5,000 m	1 hr 25 min/1 hr 53 min
at 7,000 m	1 hr 30 min/2 hrs 2 min
at 10,000 m	1 hr 44 min/2 hrs 21 min
Take-off run, m (ft):	
without drop tanks	440 (1,443)
with drop tanks	560 (1,837)
Take-off distance, m (ft):	
without drop tanks	1,075 (3,527)
with drop tanks	1,360 (4,462)
Landing run, m (ft)	540 (1,771)
Landing distance (m (ft)	1,170 (3,838)
Armament	2 x NR-23K

On 14th July 1948 one of the Yak-23 prototypes crashed in mysterious circumstances during the 'dress rehearsal' of the Tushino flypast. Investigation revealed that one of the fighter's wings was struck by a mass balance separating from the rudder of a Tu-14 ('78') bomber which, piloted by F. F. Opadchiy, was flying at a considerable distance from the Yak-23. The wing broke away and the fighter tumbled earthwards, rolling uncontrollably. The cockpit canopy was torn off and the pilot, M. I. Ivanov, was thrown clear of the aircraft, falling to his death; apparently he was incapacitated by this enforced 'ejection' and unable to open his parachute.

There were no doubts concerning the cause of the crash. Upon landing the Tu-14 was found to lack the rudder mass balance; also, traces of the green paint with which the mass balance was coated were discovered on the wing of the Yak-23 which had broken off, together with traces of the impact produced by the mass balance. Still, despite all efforts, the accident investigation board could not find the answer to the main question which boils down to the following.

There were a lot of aircraft in the air. Fighters were passing one after another at low altitude along a highway past the main grandstand. The flight altitude was roughly 100 m (330 ft). Conversely, the groups of bombers and transport aircraft were passing at high altitude and far away from the route along which the fighters were flying. Assuming that every machine remained on its predesignated route, it is indeed difficult to understand how the heavy mass balance could hit the fighter at such a long distance.

Owing to the delay in adopting the decision on the fate of the Yak-23 its production at plant No.31 did not began until 1949. Since the MiG-15 had successfully completed State acceptance trials by then, the Government took the decision to launch production of this type at several factories at once, including the one in Tbilisi. Tooling up for MiG-15 production, which began in mid-1949, diverted a considerable number of employees from the manufacture of the Yak-17 and the Yak-23 because the new machine was intended to supersede both Yaks on the production line (preparations for production of the Yak-23 had been started in February 1949). However, at the end of August it became known that the Tbilisi plant would not be building the MiG-15. Still, the tempo of tooling up for the Yak-23 had already been slackened, and the first machines were not completed until October 1949.

A total of 310 production Yak-23s rolled off the assembly lines of plant No. 31 before the end of 1950. Together with the three machines built in Moscow at plant No. 115 (including the static test airframe), the Yak-23's production run totals 313. Production fighters were powered by Soviet-built RD-500 engines (a licence-built version of the RR Derwent V) delivering 1,590 kgp (3,505 lb). Besides equipping the fighter units of the Soviet Air Force, they were supplied to some East European countries referred to in the USSR as 'countries of people's democracy'. There were plans for putting the aircraft into license production in Czechoslovakia, but they never materialised.

In the West the Yak-23 received the reporting name *Flora*.

In the Soviet Union the Yak-23 was delivered primarily to fighter regiments of the North Caucasus and Volga Defence Districts. The fighter was intended mainly for air-to-air combat at low and medium altitudes. In the opinion of pilots who flew it, the Yak-23 was a good aircraft; it was easy to fly, possessing a high rate of climb and good manoeuvrability. Among the important merits of the aircraft were its ease of maintenance and the ability to operate from grass strips.

It was in the North Caucasus area, at an airfield near the city of Groznyy, that service trials of the first production machines took place. Comments coming from the regiment's pilots were mostly favourable; notably, the fighter could easily perform aerobatic manoeuvres. However, some production defects came to light in the process of operation (for example, the cockpit canopy jammed and could not be jettisoned in an emergency; fumes from the engine cooling manifold entered the cockpit and cracks were discovered in the main undercarriage struts). There were also cases of the air bleeding from the shock absorber of the nose landing gear strut.

The Yak-23 also had a few other shortcomings which were revealed during operation of the type in other units. In flight at Mach 0.8 the aircraft became directionally unstable. The engine was installed at an angle to the aircraft's axis, which resulted in a significant pitch-up force when the throttle was advanced rapidly; this hampered the conduct of air combat where precise manoeuvring was essential. Such was the experience of the pilots who had volunteered for participation in the Korean war. Quite possibly all these shortcomings contributed to the decision to terminate production of the Yak-23.

Shortly after submitting the single-seat fighter for testing, the staff of OKB-115 developed a two-seat trainer version designated **UTI Yak-23**. In its first version, in an effort to avoid major structural changes to the single-seat machine, the engineers placed the instructor's cockpit behind the trainee's cockpit. This was the configuration of the prototype of the new dual-control aircraft built by converting the first prototype of the Yak-23 (the UTI Yak-23 retained its original c/n 115001, but the serial was changed to 50 Yellow and the original digit '3' on the rudder was replaced by a yellow '2'). However, visibility from the rear cockpit proved to be rather limited. The machine had to be modified twice. Eventually, in response to demands from test pilots, the UTI Yak-23 received a completely new layout. The engineers moved both cock-

pits forward, increasing the fuselage length in so doing. The instructor's seat was raised, resulting in curious canopy shape with a blister-like bulge above the rear seat.

Finally, the third version of the UTI Yak-23 met with approval on the part of test pilots. At an all-up weight of 3,410 kg (7,517 lb) with drop tanks the aircraft had an endurance of 1 hour 50 minutes. The top speed reached 816 km/h (441 kts) at sea level and 850 km (459.45 kts) at 5,000 m (16,404 ft). The rate of climb came very close to that of the combat version; the trainer climbed to 5,000 m within 2.5 minutes.

Like most of the trainer machines, the UTI Yak-23 had a reduced armament fit (a single 12.7-mm (.50 calibre) Berezin UB machine-gun) and equipment complement; on the other hand, a gun camera was invariably installed on the dual-control machines. The protracted testing, modification and development of the UTI Yak-23 lasted until the end of 1950 when the single-seat Yak-23 was already being phased out of production; besides, the Air Force units had already taken delivery of Yak-17UTI trainers and there was no longer any need for a trainer version of the Yak-23. Finally, the UTI Yak-23 had cramped cockpits (not surprisingly, given the aircraft's small dimensions). The trainer's insufficient range (the new cockpit 'ate up' much of the fuel tankage) also reduced the usefulness of the aircraft.

The prototype UTI Yak-23 was subsequently used by plant No. 115 for submitting an ejection seat developed in-house for State acceptance trials at GK NII VVS. This was accompanied by one interesting episode. When the two-seat trainer fitted with the ejection seat was delivered to the military institute, it was placed in a hangar. Representatives of the plant warned the military that they had better avoid approaching the ejection mechanism because this was dangerous. Work on it could only be effected by personnel who had received special instructions.

Before starting the briefing one of the OKB-115 specialists placed his foot on the seat, sat down astride the cockpit sill (facing the tail), apparently wishing to demonstrate something. At that moment the ejection mechanism fired. The luckless man was propelled out of the cockpit, sustaining a serious injury (a fractured thigh). The ejection seat was thrown up nearly to the roof of the hangar, falling squarely on the aircraft – fortunately, without damaging it. Those with a penchant for humorous comparisons immediately recalled a similar episode which had happened in Britain during the testing of the Gloster Meteor. In that case, too, a man who was supposed to give instruction to the personnel placed himself into the seat, and it fired accidentally. The seat hit the hangar roof, but the engineer escaped nearly unscathed. (One may also recall John Damian who, in 1507, jumped from the walls of Stirling Castle in Scotland, wishing to fly to France on home-made wings, but instead 'fell to the ground and brak his thee bane' (thigh bone) – just like the involuntary ejectee.)

This is how the first ejection of a 'Yakovlev seat' was effected at GK NII VVS. Moral: doctor, heal thyself!

In accordance with the directive of the Council of Ministers No. 760-288ss dated 22nd February 1949 the Yak-23 was used for conducting ground experiments associated with the development of a system for towing a jet fighter behind a Tu-2 bomber. Then the towing method thus evolved was verified during flight tests of the automatic coupling of the Yak-25 jet fighter to a North American B-25 bomber (see Chapter Three for more details).

Two examples of the aircraft have been preserved in Russia. A standard single-seat Yak-23 with the tactical code 15 Red is part of the Monino museum's collection, while the Yakovlev OKB has managed to preserve the sole example of the dual-control machine (painted grey-green overall, with no insignia whatever and with a new rear cockpit canopy resembling the original second version; apparently the bulged canopy was lost somehow). The trainer was exhibited at Moscow-Khodynka airfield in August-September 1993 during the MAKS-93 airshow.

The Yak-23 was in the inventory of the air forces of a number of 'friendly nations'.

Albania: It is known that the first Yak-23s were delivered to the Albanian People's Republic Air Force (*Forcat Ushtarake Ajore Shquipëtare*) in 1951. It is also known that a certain number of these aircraft, still operational, and a large amount of spares for them was transferred to Albania from Poland.

Bulgaria: The Bulgarian Air Force introduced the Yak-23 in 1949. Initial deliveries are known to have been 12 aircraft but the total number of Yak-23s supplied to Bulgaria is unknown. There have been reports in the press that Bulgaria attempted to develop a two-seat trainer version of the *Flora*, but so far no confirmation has been found. Two Yak-23s are preserved in the BVVS museum at Graf Ignatiev AB in Plovdiv, home of the 19th IAP (Iztrebitelen Aviopolk).

Czechoslovakia: The Czechoslovak Air Force was the first foreign operator of the type. Czechoslovakia even intended to start licence production of the Yak-23, but eventually opted for the more advanced MiG-15. Again, the first 12 aircraft were delivered to the CzAF in late 1949, almost concurrently with the Yak-23's service entry with the Soviet Air Force; later Czechoslovakia received a further nine examples. Until the mid-1950s the CzAF had a habit of allocating its own designations to foreign-designed and/or -built aircraft in Czech service; hence the Yak-23 was known locally as the **S-101**, the S denoting *stíhací [letoun]* – fighter; its RD-500 engine was also redesignated, becoming the M-02.

The Yak-23 (S-101) supplanted the Supermarine Spitfire Mk. IX (aka the S-89) and the Messerschmitt Bf 109G (manufactured locally from German components and designated S-99). The first Czechoslovak airbase to host the new jets was Cheb (Pronounced 'Kheb'), followed soon after by Brno-Turany AB.

The type starred in the very first colour movie about the Czechoslovak Air Force called *Modry Den* (Blue Day); all known air-to-air pictures of CzAF Yak-23s are stills from that movie. In the 1970s the Czechoslovak plastic kit manufacturer KP (*Kovozávody Prostéjov* – Prostéjov Metalworks) released a reasonably accurate model of the Yak-23 to 1/72nd scale.

Romania: The first 12 Yak-23 fighters were delivered to Romania in 1951. In all, the Romanian Air Force (*Fortele Aeriene ale Republicii Socialiste Române*) received 40 machines of this type. In 1956 one of the available fighters was converted into a two-seat training version. The project was evolved by CTIA, the military aeronautical institute located in the town of Piperz. The aircraft received the designation Jak-23DC (*dubla comanda*, ie, dual-control). The second cockpit was inserted in the aft fuselage, taking up the place previously occupied by the rear fuel tank; the front cockpit remained in its normal position. The fuselage section between the glazing of the new cockpit and the fin was suitably modified. The front cockpit was occupied by the trainee, the instructor sitting in the back seat. The aircraft had no armament.

Hungary: Yak-23 fighters were on the strength with the Hungarian Air Force (MHRC – *Magyar Honvedseg Repülö Csapatai*) from 1950 to 1956, but no exact figures about their number are available.

Poland: The first Yak-23s reached Poland in December 1950. The crated aircraft were delivered by rail and road to hangar No. 1 at Bemowo AB near Warsaw. Besides a disassembled aircraft, each crate contained a box with instruments and spare parts. The aircraft was stowed in the crate as follows: the detachable forward fuselage was placed vertically, the fuselage complete with the engine and vertical tail was placed horizontally; the wings and stabilisers were placed in the same fashion. Later the Polish Air force received nine aircraft from Czechoslovakia and a certain number of Yak-23s from units of the Soviet Air Force. The total number of aircraft of this type employed by the PWL exceeds 100.

The aircraft delivered in the first batch were assembled by Soviet specialists who

Above and below: The prototype of the UTI Yak-23 trainer as originally flown.

A three-quarters rear view of the same aircraft. Note the canopy design.

concurrently trained the Polish ground crews. The reassembled machines were test-flown by Soviet instructors who had been sent to undertake conversion training of Polish pilots in situ. Starting in April 1951, the newly assembled machines were reflown by Polish pilots from the first group of airmen who had received training on this aircraft type. They also became the first instructors who were granted the right to undertake training on jet aircraft. In January 1951 these pilots were sent on a mission to fighter air regiments of the Soviet Union's Air Force. The first group included 12 pilots: Capt. Boychikov, the already mentioned Capt. Vasiliy Gashin, *podporucznik* Andrzej Dobrzeniecki, Capt. Mieczyslaw Goworek, *podporucznik* Wladyslaw Hermaszewski, *podporucznik* Wiktor Iwon, Capt. Tadeusz Krepski, Capt. Stefan Ploszanski, Capt. Eugeniusz Pniewski, *podporucznik* Boleslaw Smolik, Capt. Stanislaw Tanana and Capt. Stanislaw Wiacek .

The training included a theoretical course and flying practice. Initially the training was conducted on Yak-17UTIs. Each of the Polish pilots performed an average of 13 flights with a qualified flying instructor and two check flights. Every flight lasted for 10 to 15 minutes, which gave a total flying time of about three hours. After this, some of the pilots came back to their units where they, after weekly theoretical studies and after passing exams were trained by Soviet instructors on the Yak-23s; other pilots continued their training on this fighter type in Soviet units. The total flying time logged on both types (the Yak-17UTI and Yak-23) amounted to about 10 hours. It was these pilots that made up the first group of Polish instructors who trained other pilots converting to jet aircraft.

Concurrently with new deliveries of new hardware most of the pilots of the 1st and 2nd Fighter Air Regiments of the Polish Air Force (1. PLM 'Warszawa' and 2. PLM) underwent conversion training. As early as September 1951 squadrons commanded by Maj. Ulanowski and Capt. Rybacki were granted the right to be on combat duty. For the first time mock combats between jet aircraft were staged for training purposes in the skies of Poland. A while earlier, on 26th August 1951, the Yak-23 was presented to the public for the first time on occasion of the Aviation Day. The show took place at Warsaw-Okecie airfield. Among the aircraft shown in the air was a group of the Yak-23s, and, by way of concluding the show, Maj. Stanislaw Tanana, Maj. Stanislaw Wiacek and Capt. Kazimierz Tanana performed group aerobatics in these aircraft.

The Yaks were also demonstrated on 22nd July 1952. On that day inauguration of the Dzierzinski Square took place in Warsaw; on that occasion a flypast was staged and aircraft from three regiments were allotted for participation in it. Lt. Col. Vasiliy Bystrov was the commander of the flypast. A group of 18 Yak-23 fighters made a fly-by in a formation comprising six flights of three aircraft. One of the aircraft of the last three-machine flight (serialled '10 Red') was piloted by Lt. Wladyslaw Hermaszewski who subsequently became a well-known general.

Hermaszewski voiced the opinion that the Yak-23 was the most manoeuvrable fighter of all the types that he had flown.In his opinion, the fighter was overpowered. Not infrequently the pilots retracted the undercarriage immediately after lift-off, not at the altitude prescribed by the flight manual; this was followed by quick acceleration and a brisk climb to altitude. Importantly, the Yak-23 did not require specially prepared airfields. On several occasions the aircraft landed at airstrips that just chanced to be available, sustaining no damage. One of the Polish trainees landed on a small grass airfield intended for sports aircraft. Having inspected the aircraft, the squadron commander flew it back to base from the same airstrip. In the opinion of Polish pilots, the Yak-23 possessed the best performance for its time among jet aircraft with unswept wings.

The Yak-23 aircraft remained in the first line of Poland's Air Defence until the end of 1955 and the beginning of 1956, whereupon

Above: This is the second version of the UTI Yak-23's canopy; a gun camera is fitted on top of the windshield.

Two views of the UTI Yak-23 following its second update. Note the dipole aerials of the radio altimeter under the port wing and port stabilizer.

Above and below: Two views of the UTI Yak-23's canopy in its ultimate configuration. Note how the aft portion of the sliding rear canopy lifts up on a special rocker lever.

it was gradually supplanted by more modern aircraft. Whereas the 1. PLM and 2. PLM had these aircraft on strength from 1951, other units received these aircraft in 1952 and 1953.

The Yak-23s were also placed at the disposal of the Officers' Flying School No.5 in Radom, which specialised in training pilots for fighter units. The trainees performed their first flights on the Yak-17W (Yak-17UTI), after which they transitioned to the Yak-23. The first aircraft of this type appeared in the school in 1953 and were used until 1957. The fighters which came into the school mainly from the 1st and 2nd regiments formed three squadrons. The first of them was commanded by Maj. Lipczynski, the second by Maj. Gotlib, the third by Tomasz Mazowiecki. In 1957 the first flight of the first squadron was commanded by Capt. Wlodzimierz Wiciejowski who logged 7 hours 26 minutes on the Yak-23, having performed a total of 51 flights on this type. The school had no fewer than thirteen Yak-23s.

In the early 1950s the Polish aircraft industry began preparations for manufacturing the Yak-23 under licence. The production was to be take place at WSK Mielec and WSK Swidnik . The fighter was expected to be allocated the Polish designation **G-3**. The Mielec aircraft factory was to manufacture wings and tail units and to assemble the aircraft. In this connection one Yak-23 was delivered to Mielec to serve as a pattern aircraft for series production. The aircraft was strictly guarded, and only the few people immediately engaged in the preparation for production had access to it. Among those granted access was engineer Ludwik Giryn who was dealing with the aircraft's internal equipment.

The plant in Swidnik was to manufacture the forward fuselage sections. Tooling up for production was conducted under the direction of engineers Jerzy Kotlinski and Zbigniew Klimkiewicz. The plant's design bureau had already started the manufacture of mold lofts. Preparations in Swidnik gathered pace very quickly; this is borne out by the fact that after the termination of the work 25 tonnes of half-finished duralumin articles and finished elements of the aircraft's structure were sent to the smelter.

In 1956 the command of the Polish Air Force handed two Yak-23 over to the Aeronautical Institute in Warsaw. The aircraft were placed on the Polish civil register as SP-GLK and SP-GLL. The latter aircraft, however, did not fly, being cannibalised for spares to keep SP-GLK airworthy. The jet enabled the institute to expand the scope of research work.

The many experiments conducted on Yak-23 SP-GLK included evolving the methods of flutter tests. The aircraft was also intended for use as a testbed for ramjet engines, work on which was conducted in Poland in the late 1950s. The ramjets were to be installed under the wings close to the fuselage, so that an eventual flameout of one of the engines would result in minimum thrust asymmetry. However, these tests were never in fact started.

On the other hand, it is worth noting that on 21 September 1957 test pilot Andrzej Ablamowicz performed a record-breaking flight in SP-GLK; he climbed to 3,000 m (9,842 ft) within 119 seconds and to 6,000 m (19,685 ft) within 197 seconds, setting two international time-to-height records. Although the record was established on a specially prepared aircraft, this bore witness to its high performance because by that time the Yak-23 was already considered to be an obsolete fighter type.

The record-breaking aircraft became a champion of longevity among Polish Yak-23s. Its civil registration was cancelled as late as 28th November 1961; two years later it fell into disrepair and was scrapped.

One of the ex-Polish Air Force Yak-23s aptly serialled 23 (the c/n has been reported as 1017 but the true c/n is presumably 3123017) was handed over to the Polish Armed Forces Museum (*Muzeum Wojska Polskiego*) in Warsaw in 1957 (it remains the museum's exhibit to this day, albeit as 12 Yellow). One more machine serialled 16 was handed over to the Aerospace Museum in Kraków in 1963.

USA: One Yak-23 mysteriously found its way to the United States and was evaluated at Wright-Patterson AFB. Its origins remain classified to this day, but it was most probably a defector from Poland.

Yak-23 '12 Yellow' is on display at the Polish Armed Forces Museum (*Muzeum Wojska Polskiego*) in Warsaw.

Chapter 3

Yak-19 and Yak-25

Yakovlev's last straight-wing fighters

Development of the aircraft in question was initiated by the Council of People's Commissars directive No. 952-397ss of 29th April 1946 (the appropriate NKAP order No. 282ss followed on 8th May). These documents tasked several design bureaux with developing and building tactical fighters powered by a single turbojet engine designed by Arkhip Mikhaïlovich Lyul'ka's OKB-165. According to the general operational requirement the aircraft was to have a top speed of 850 km/h (459 kts) at sea level and 900 km/h (486 kts) at 5,000 m (16,404 ft), a range of 700 km (434 miles) in optimum cruise mode, a service ceiling of 14,000 m (45,931 ft) and climb to 5,000 m in 3.8 minutes.

The Yak-15 and Yak-17 developed in the first 18 post-war months employed thick wing airfoils which made it impossible to reach the specified high speeds. Besides, the RD-10 turbojet powering these aircraft (a Soviet copy of the Junkers Jumo 004B which also powered Lavochkin's '150' and '150M' experimental fighters) was rated at only 900 kgp (1,984 lb st). Trials of the first jet fighters originating from the Yakovlev and Lavochkin bureaux showed clearly that this low-powered engine gave no chances of developing a truly capable combat aircraft. The government was well aware of this, hence the abovesaid Council of People's Commissars directive required the fighters to be designed around the more powerful Lyul'ka engine which was designated TR-1.

Still, Lyul'ka was making slow progress with his firstling and the TR-1 was unavailable at the time; the engine did not commence bench running until July 1946. The test cycle was completed in March 1947 when the TR-1 successfully passed its State acceptance trials. Thus the government's demands could not be met as far as the powerplant was concerned. However, the government order for the new jet fighter was still there, so Yakovlev OKB engineers proposed uprating the production RD-10 as a stopgap measure. An afterburning version of the RD-10 was designed jointly by OKB-115 and the Central Institute of Aero Engines (TsIAM). The afterburner was fitted instead of the standard nozzle, featuring a simple variable nozzle with two flaps for adjusting the nozzle area; OKB-115 engineer B. S. Motorin and TsIAM laboratory chief A. A. Lokshtovskiy contributed a lot to the development of the afterburner.

Bench running tests of the modified engine proceeded in February and May 1946; it was sometimes referred to as the RD-10F (*for**see**rovannyy* – uprated, or, in this context, afterburning) but this designation is rarely found in official documents. Experiments held at this stage showed that the engine posed no danger of a fire in the event of a fuel leak. Later the RD-10F was put through its paces on a North American B-25J Mitchell bomber converted into an engine testbed, showing an afterburner rating of 1,100 kgp (2,425 lb st). A separate trials programme was held to determine the afterburner's service life, using a special test rig built by LII. Finally, a report showing that the RD-10F had successfully passed a 26-hour test programme was signed on 4th May 1946, enabling the Yakovlev OKB to embark on the development of a new fighter in the middle of the year.

The specific operational requirement issued on 1st August 1946 set an extremely tight development schedule; the design work was to be completed in just 50 days, including 15 days for the advanced project stage and 30 days for full-scale mockup construction. To give credit where credit is due, OKB-115 managed to design and build the new fighter in just four months – prototype construction was completed on 29th November 1946.

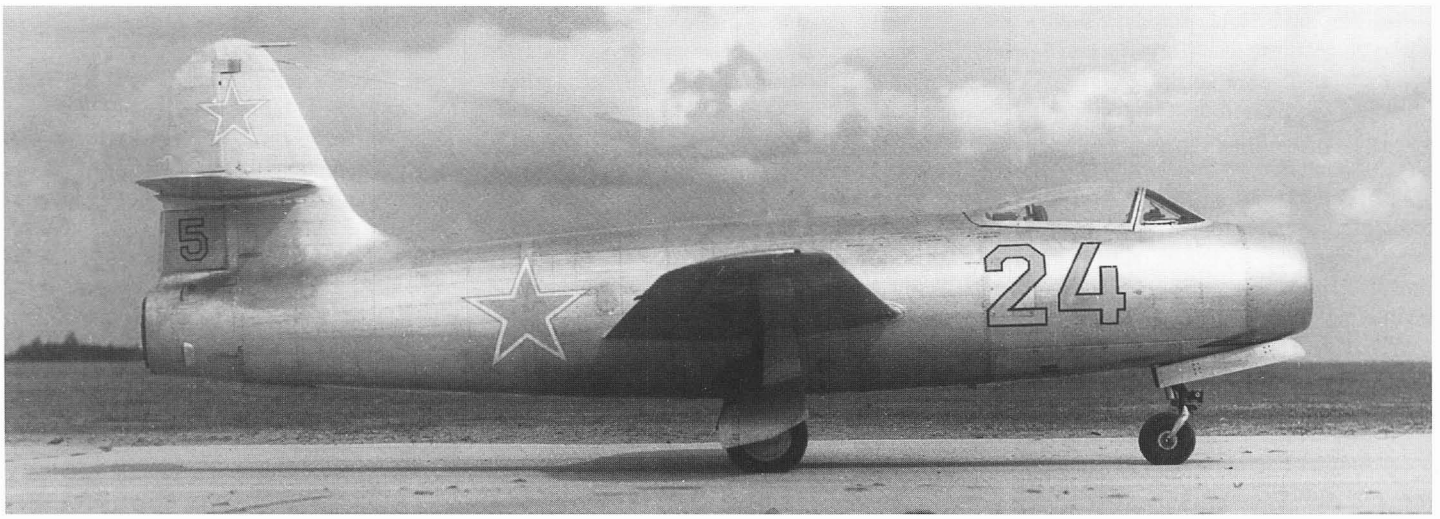
Designated **Yak-19**, this was the first all-metal aircraft to originate from the Yakovlev OKB. Until then, all Yakovlev designs had been of mixed construction, utilising a welded steel-tube fuselage truss with plywood, metal or fabric skin, wings with wooden or metal spars and plywood/fabric skin, and fabric skinning on all control surfaces. Despite the extremely limited time available, the engineers did an excellent job, meeting all design specifications except empty weight – the aircraft was 225 kg (496 lb) overweight (much to the annoyance of Aleksandr S. Yakovlev who always prided himself on the high weight efficiency of his designs).

Initially L. M. Schekhter was the Yak-19's chief project engineer. Later he was succeeded in this capacity by N. K. Skrzhinskiy, who in turn was succeeded at the flight test stage by Leonid L. Selyakov who had joined the Yakovlev OKB a short while earlier after the closure of the Myasischchev design bureau. (Vladimir M. Myasischchev's OKB-23 had been disbanded in January 1946 as redundant in the light of the transition to peacetime economy but was eventually reinstated when the mounting tensions of the Cold War led to the need for more bombers.) It was under Selyakov's guidance that a full-scale wooden mock-up showing the layout of all control runs, piping, wiring etc. was built for the first time in OKB-115 practice.

Outwardly the Yak-19 was very different from the rather ungainly Yak-15 and Yak-17 fighters; in fact, the chosen general arrangement became a sort of standard for many fighters developed in the USSR during the 1950s and 1960s. The Yak-19's design incorporated a number of revolutionary features which found active support not only from Yakovlev himself but from his closest aides – K. A. Vigant, S. Ya. Makarov and the OKB's chief technologist S. S. Bekin. The pod-and-boom layout with the engine(s) in the forward fuselage shared by the first Soviet jet fighters gave way to a more aerodynamically efficient arrangement with the engine buried in the aft fuselage, exhausting through the latter's extremity via a long extension jetpipe – for the first time in Soviet design practice. The monocoque fuselage had a production break aft of the wings which allowed the entire aft fuselage to be removed for access to the engine, facilitating engine maintenance or removal. The Yak-19 was also the first Soviet aircraft to be powered by an afterburning turbojet. The unpressurised cockpit was located well forward, which significantly improved cockpit visibility; the pilot was provided with an ejection seat and protected by a 57-mm (2.24-in.) bulletproof windscreen, a 6-mm (0.23-in) forward armour plate and an 8-mm (0.31-in.) armoured seat back.

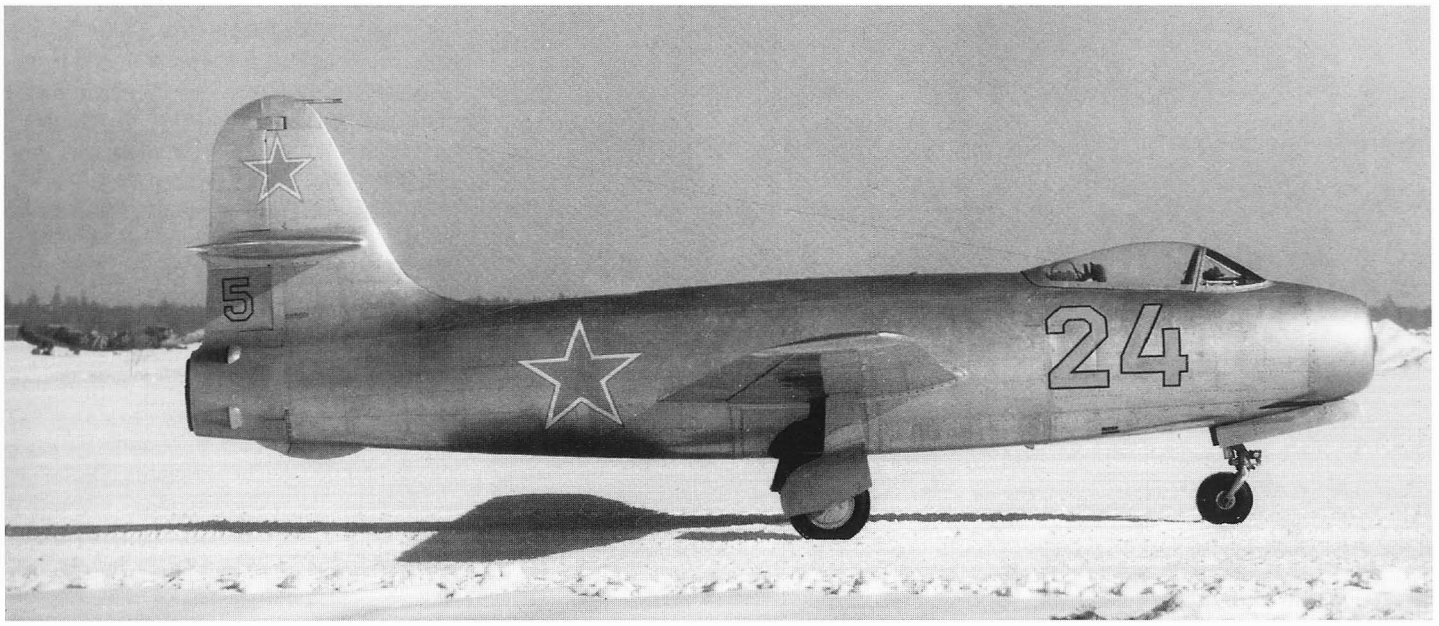
The Yak-19 had mid-set two-spar wings of trapezoidal planform, with a span of 8.72 m (28 ft 7.3 in.) and an area of 13.56 m² (145.8 sq. ft). The relatively thin wings with a 12% thickness/chord ratio at the root employed the TsAGI S-1-12 laminar airfoil verified on the Yak-RD-10 (Yak-RD) experimental fighter in the summer of 1946; they featured TsAGI flaps (modified Fowler flaps) and Frise ailerons with a TsAGI KV-3-12 laminar airfoil.

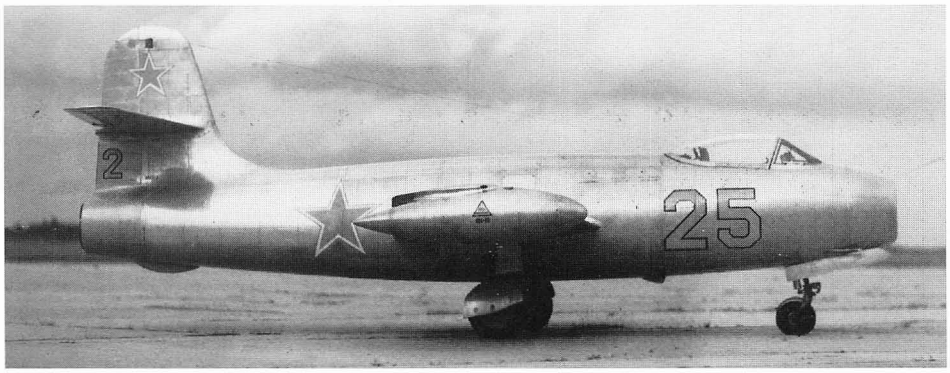
Above: 24 Yellow, te first prototype Yak-19 (c/n 01115001), during a test flight.



Above and below: The numeral '5' on the rudder of the first prototype was meant to deceive spies. Note the c/n painted at the base of the fin and afterburner cooling louvres immediately ahead of the engine nozzle.

Three more views of the first prototype Yak-19 during manufacturer's flight tests. Quite possibly the Yak-19 was not the most elegant fighter jet, but it was certainly an improvement on the preceding pod-and-boom designs!

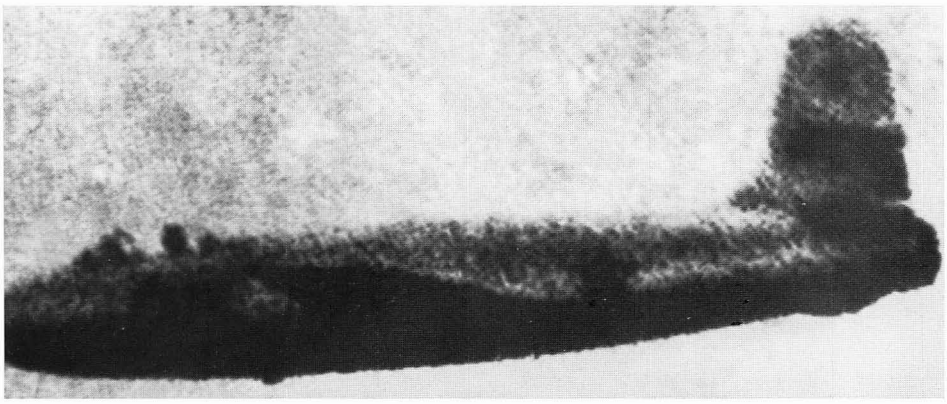




Top, centre and above: Appropriately enough, 25 Yellow, the second prototype, was marked 2 Yellow on the rudder. Note the drop tanks carried in the same fashion as on previous Yakovlev jets.

The cruciform tail unit had a stabilizer span of 3.5 m (11 ft 5.79 in.); vertical tail area and horizontal tail area was 2.025 m² (21.77 sq. ft) and 3.0 m² (32.25 sq. ft) respectively.

The tricycle landing gear comprised a forward-retracting nose unit with a 400 x 150 mm (15.7 x 5.9 in.) wheel and inward-retracting main units, the 570 x 140 mm (22.44 x 5.51 in.) mainwheels stowing in the centre fuselage. The Yak-19 was armed with two 23-mm (.90 calibre) Shpital'nyy Sh-3 cannons with 75 rounds each. Avionics and equipment included an RSI-6 radio, an RPKO-10M direction finder, an SCh-3 IFF transponder, a GSK-1200 generator, a 12-A-10 DC battery, a PAU-22 gun camera, a KP-14 breathing apparatus with a 2-litre (0.44 Imp. gal.) oxygen bottle etc.



A poor-quality but interesting shot depicting the second Yak-19 at the 1947 Tushino flypast.

Serialled 24 Yellow and bearing the yellow numeral '5' on the rudder, the first prototype Yak-19 (c/n 01115001 – ie, Batch 01, Moscow Machinery Plant No. 115, first aircraft in the batch) was cleared for manufacturer's flight tests on 29th November 1946. Next day the aircraft was trucked to the nearby Central airfield (Khodynka) to begin taxiing trials. On 12th December the Yak-19 suffered a fire when technician Sbitnev started the engine as part of the ground tests; a substandard gasket in a fuel line gave way, causing the fuel to leak out and ignite. After repairs which took two weeks the prototype was trucked to LII's airfield in Zhukovskiy on 26th December and taxiing trials resumed there the following day. Finally, on 8th January 1947 the Yak-19 performed its maiden flight with Col. Mikhail I. Ivanov (Hero of the Soviet Union) at the controls. Sergey N. Anokhin was the Yak-19's project test pilot for the rest of the manufacturer's flight test programme.

The aircraft had to be grounded from 2nd March to 18th May for an engine change; the long lay-up was caused by the late delivery of the replacement engine. As already mentioned, the Yak-19 was the first Soviet aircraft to be powered by an afterburning turbojet – but not the first to actually use afterburning; the afterburner was not ignited in flight until 21st May 1947, ie, more than a month later than on Lavochkin's rival 'aircraft 156' (La-156) fighter. On that occasion the afterburner was engaged at 3,000 m (9,842 ft), increasing the fighter's indicated airspeed from 580 km/h (313.5 kts) to 670 km/h (362 kts). A second attempt was made on 22nd May and the Yak-19 accelerated from 600 km/h (324 kts) to 700 km/h (378 kts) when the afterburner kicked in.

The second prototype (c/n 115002) joined the test programme in the summer of 1947; it was referred to in official documents as the 'Yak-19 *doob**lyor***' (lit. 'understudy'; the Soviet term for second prototypes used until the late 1960s) and differed in having fittings for drop tanks under the wingtips. Serialled 25 Yellow and marked '2 Yellow' on the rudder, this aircraft first flew on 6th June at the hands of Sergey N. Anokhin.

All in all the manufacturer's flight tests included 64 flights; the first prototype made 27 flights and the second prototype 37, logging 23 hours 30 minutes between them. The Yak-19 became the first Soviet aircraft to crack 900 km/h (486 kts); with a 3,000-kg (6,613-lb) TOW the fighter had a top speed of 904 km/h (488.6 kts) at 5,000 m (16,404 ft), reaching this altitude in 3.9 minutes with the afterburner engaged. Anokhin reported that

the Yak-19 presented no problems for the average pilot; the fighter easily performed the entire range of aerobatics, including inverted flight.

The manufacturer's flight test report was signed on 27th September 1947. It said: *'The Yakovlev-19 aircraft powered by an afterburning RD-10 turbojet has duly completed manufacturer's flight tests and can be submitted for State acceptance trials at GK NII VVS.'*

The test programme included canopy jettison trials; the process was filmed by a movie camera from a chase plane to determine the canopy's trajectory after separation. When the canopy locks were released the sliding portion popped up about an inch, then rotated rear end uppermost and slid aft along the fuselage in this nearly vertical position, leaving deep scratches in the fuselage skin as it did. Moving to one side, the canopy finally fell clear of the aircraft, but the fuselage was severely damaged.

Back in the spring of 1947 Minister of Aircraft Industry A. I. Shakhoorin had issued an order requiring General Designer and Director of MMZ No. 115 A. S. Yakovlev to *'speed up flight tests of two Yak-19 fighters with afterburning RD-10 gas turbine engines so as to submit them for State acceptance trials in May.'* However, the protracted construction of the second prototype caused the manufacturer's flight tests to last longer than anticipated, which meant the deadline stated in this document could not be met.

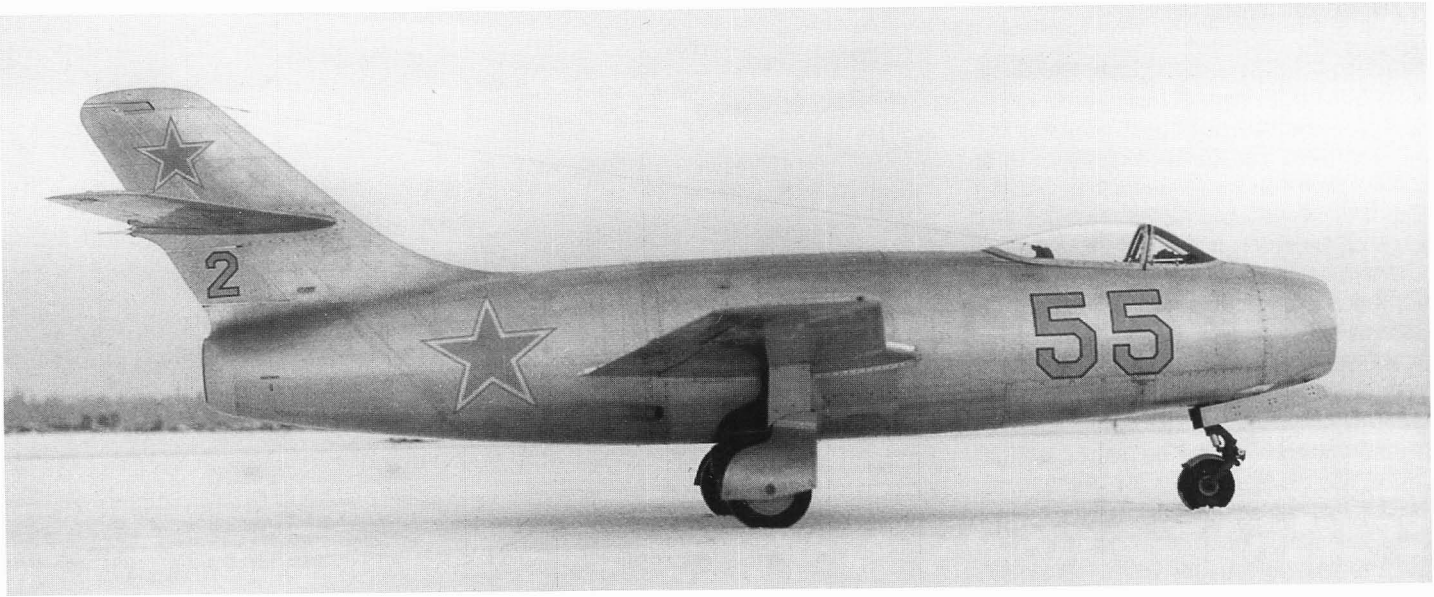
On 3rd August 1947 the second prototype Yak-19 piloted by Sergey N. Anokhin led a group of jet aircraft from various bureaux during the traditional flypast at Tushino airfield. Exactly two months later, on 3rd October, this aircraft was turned over to GK NII VVS for State acceptance trials which lasted from 17th October 1947 to 30th January 1948. Lt. Col. A. G. Proshakov was assigned project test pilot and Capt. V. P. Belodedenko was the engineer in charge of the tests. At this stage the Yak-19 showed a top speed of 907 km/h (490.2 kts) in afterburner mode at 5,000 m (16,404 ft) with a 3,050-kg (6,724-lb) TOW, reaching this altitude in four minutes. The service ceiling was 12,100 m (39,698 ft). At full military power the fighter reached a top speed of 782 km/h (422.7 kts), climbing to 5,000 m in 7.7 minutes. Range in 'clean' configuration was 550 km (341 miles), increasing to 895 km (556 miles) with drop tanks.

The Yak-19's specifications are detailed in the table on this page.

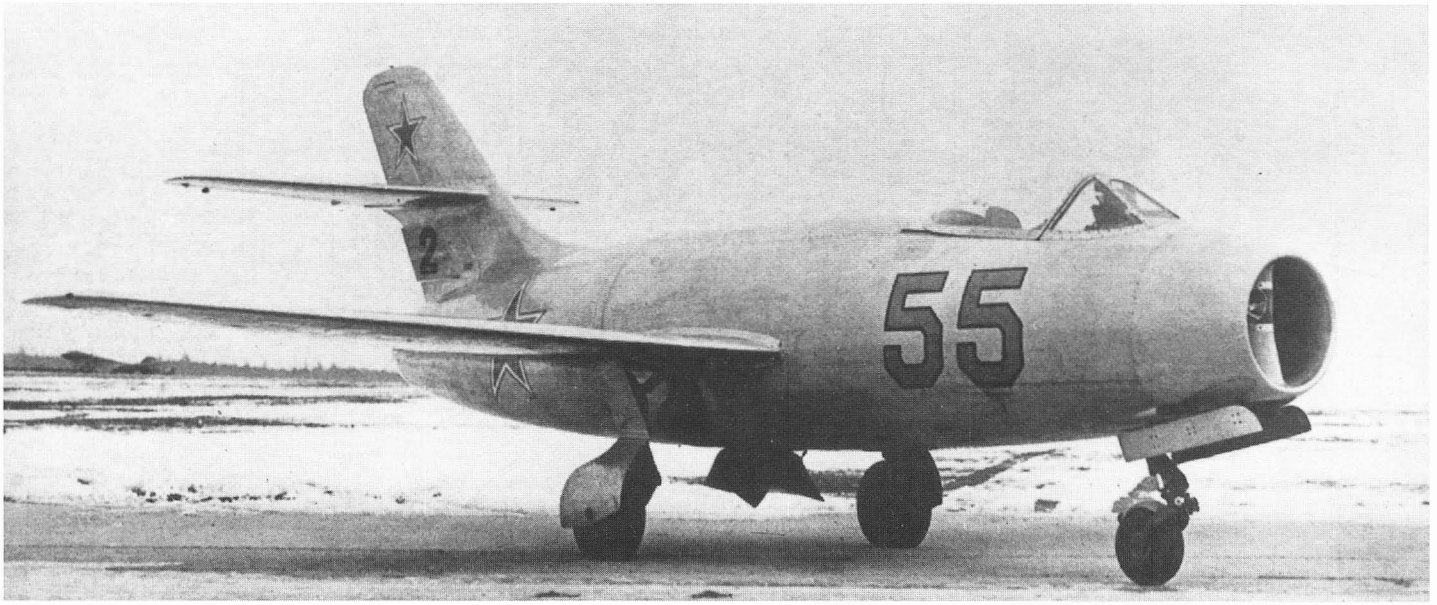
Using the afterburner for take-off reduced the take-off run by some 24% and the take-off distance by 20%. Top speed at high altitude increased by 125 km/h (67.5 kts), or by 102 km/h (55.1 kts) as compared to the Yak-15's top speed. The State acceptance trials showed that the Yak-19 met all the perfor-

	ADP project	Manufacturer's flight tests	State acceptance trials
Length overall	8.36 m (27' 5.13")	8.36 m (27' 5.13")	8.357 m (27' 5.01")
Wingspan (less drop tanks)	8.70 m (28' 6.52")	8.70 m (28' 6.52")	8.72 m (28' 7.3")
Wing area, m² (sq. ft)	13.50 (145.16)	13.50 (145.16)	13.56 (145.80)
Operating empty weight, kg (lb):			
without drop tanks	1,990 (4,387)	2,192 (4,832)	2,151 (4,742)
All-up weight, kg (lb):			
normal (in 'clean' condition)	2,800 (6,173)	3,000 (6,613)	3,050 (6,724)
maximum (with drop tanks)	n.a.	3,350 (7,385)	3,400 (7,495)
Power loading, kg/kgp (lb/lb st)	2.54	2.91	2.74
Top speed at full military power/ with afterburner, km/h (kts):			
at S/L	n.a./880 (n.a./475.6)	760/875 (410.8/473.0)	714/n.a. (386.0/n.a.)
at 5,000 m (16,404 ft)	n.a.	818/904 (442.16/488.64)	n.a.
at 5,250 m (17,224 ft)	n.a.	n.a.	n.a./907 (n.a./490.27)
at 5,750 m (18,864 ft)	n.a.	n.a.	782/n.a. (422.7/n.a.)
at 7,000 m (22,965 ft)	n.a./900 (n.a./486.4)	n.a.	n.a.
at 10,000 m (32,808 ft)	n.a.	788/875 (426.0/473.0)	747/n.a. (403.78/n.a.)
Landing speed, km/h (kts)	165 (89.2)	180 (97.29)	155 (83.78)
Time to height, minutes:			
to 5,000 m (16,404 ft)	n.a./4.0	n.a./3.9	7.7/4.0 *
to 10,000 m (32,808 ft)	n.a.	n.a./10.5	24.0/n.a.
Rate of climb, m/sec (ft/min):			
at S/L	n.a.	16.4/25.8	13.8/23.0 (2,715/4,526)
at 5,000 m (16,404 ft)	n.a.	n.a	8.3/17.8 (1,633/3,503)
at 10,000 m (32,808 ft)	n.a.	n.a.	2.8/n.a. (551.0/n.a.)
Service ceiling, m (ft)	12000	n.a.	12100
Max. range, 'clean'/w. drop tanks, km (miles):			
at 7,000 m (2,965 ft)	n.a.	n.a.	550/895 (341/556)
at 8,000 m (26,246 ft)	n.a.	n.a.	580/970 (360/602)
at 9,000 m (29,527 ft)	700/n.a. (434/n.a.)	n.a.	n.a.
at 10,000 m (32,808 ft)	n.a.	700/1000 (434/621)	n.a.
Endurance without/with drop tanks:			
at 7,000 m (2,965 ft)	n.a.	n.a.	0 h 59 m/1 h 33 m
at 8,000 m (26,246 ft)	n.a.	n.a.	1 h 10 m/1 h 44 m
at 9,000 m (29,527 ft)	n.a.	n.a.	0 h 55 m/1 h 27 m
Take-off run in 'clean' condition (full military power/full afterburner), m (ft)	n.a./600 (n.a./1,968)	n.a./550 (n.a./1,804)	685/550 (2,247/1,804)
Take-off run with drop tanks (full military power/full afterburner), m (ft) (3,304/2,214)	n.a.	n.a.	925/675
Landing run, m (ft)	n.a.	520 (1,706)	550 (1,804)

*Note: * Climb time to 5,000 m (16,404 ft) with drop tanks is 4.4 minutes.*

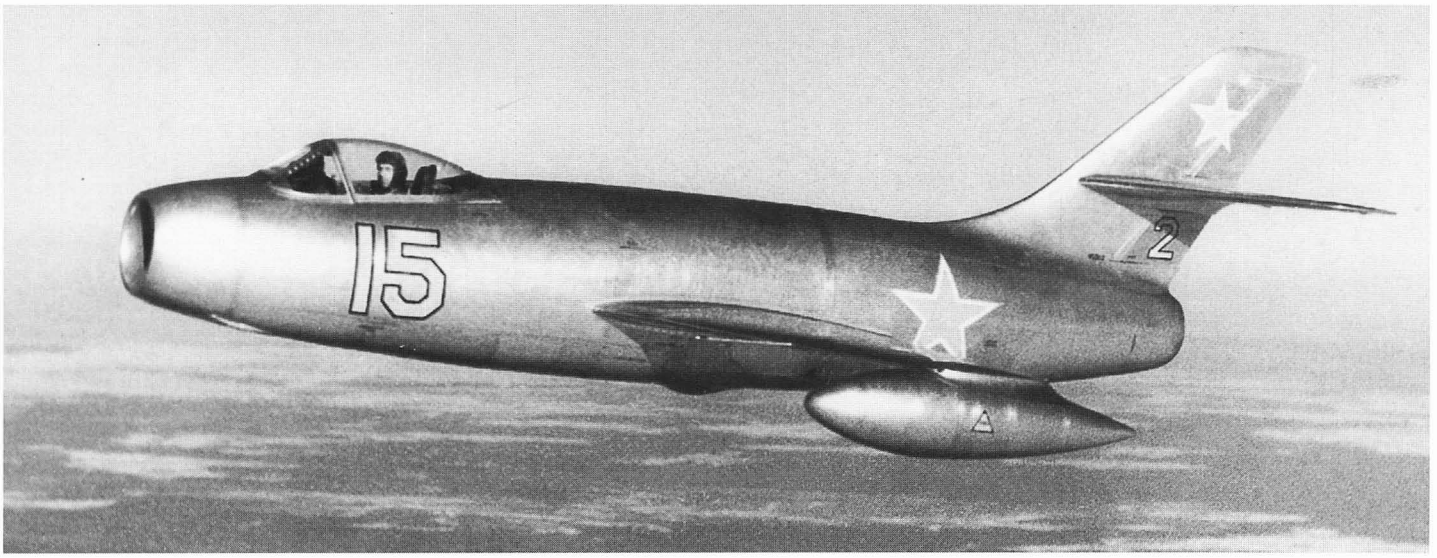


Three views of 55 Yellow, the first prototype Yak-25, during manufacturer's flight tests.

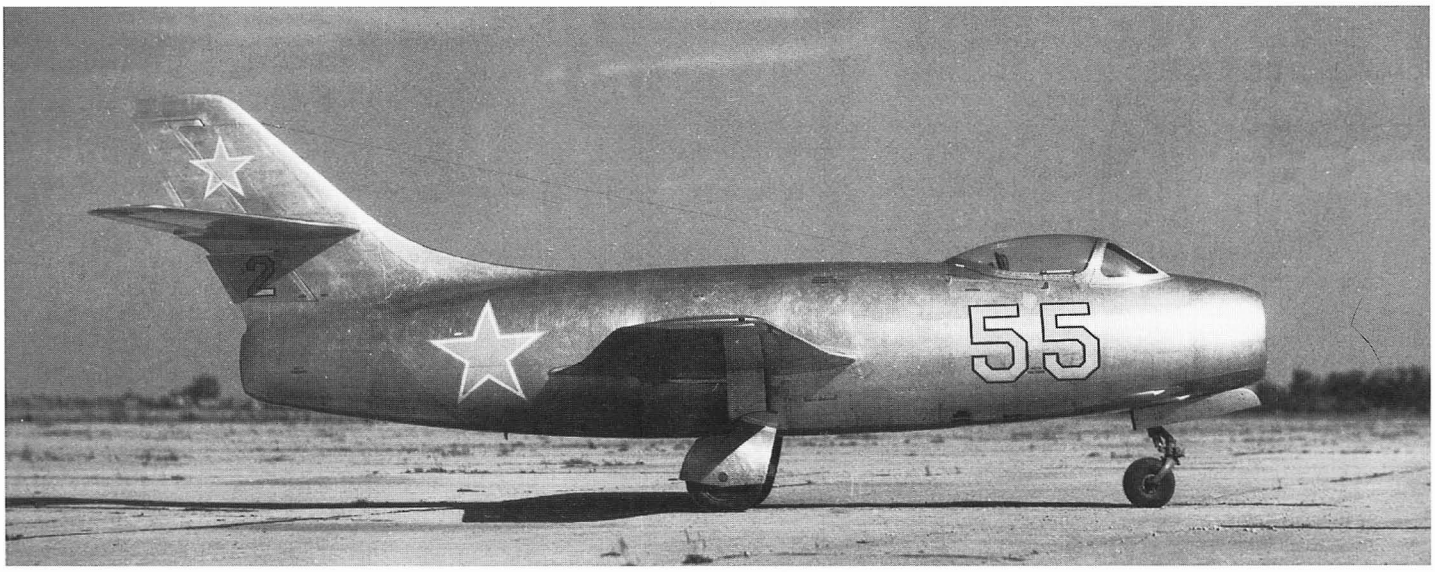


Above: The first Yak-25 (c/n 115001) seen during State acceptance trials.

Above: 15 Yellow, the second prototype Yak-25 (c/n 115002). Note that the numeral on the rudder is the same.



An air-to-air shot of the second prototype Yak-25 with drop tanks during a test flight.



Top and above: No, this is not the first Yak-25, prototype, it is the third one (c/n 115003)! Compare the fin cap shape to the aircraft on page 94.

'Aircraft 03' with drop tanks at the GK NII VVS airfield during State acceptance trials.

mance figures stated by the manufacturer. The trials report released by GK NII VVS (curiously, this document was not signed until 8th May 1948, more than three months after the completion of the trials!) said, among other things: *'Uprating turbojet engines by combusting additional fuel in the jet nozzle is an effective way of increasing engine thrust during take-off and climb, as well as in level flight for a period of 2-4 minutes.'*

However, the report also mentioned numerous problems and shortcomings. For instance, Item 3 of the report's concluding part said:

'3. The State acceptance trials of the Yak-19 showed that:

- *afterburner operation is unreliable and the afterburner cannot be used in air-to-air combat due to the problems associated with controlling it;*
- *the aircraft has numerous deficiencies, namely high stick forces required to operate the ailerons, the lack of heating and ventilation systems in the cockpit, inadequate armour protection etc.'*

In Item 4 of the Conclusion the military stated their verdict unambiguously: *'...the Yak-19 fighter powered by the a/b RD-10 engine cannot be recommended for Air Force service.'*

Instead of building a third prototype with appropriate modifications and refining the afterburning version of the RD-10 to a degree when it could be put into production (as was normal practice at OKB-115), Yakovlev chose to pull the plug on the Yak-19. The reason was that in early 1948 the Soviet aircraft industry had launched production of the new RD-500 non-afterburning centrifugal-flow turbojet – a licence-built version of the Rolls-Royce Derwent V delivering 1,590 kgp (3,505 lb st) for take-off. The PD section of OKB-115 did begin preliminary calculations for a Derwent-powered version of the Yak-19 but this aircraft was never built because the OKB had already developed two new fighters designed around this engine – the Yak-23 (see previous chapter) and Yak-25. The former first flew in the summer of 1947 and, after successfully completing its test cycle, was put into production at the Tbilisi aircraft factory No. 31; the other fighter entered flight test in October 1947. Nevertheless, afterburners were quickly brought up to an adequate reliability level, becoming standard equipment on all jet fighters designed from the mid-1950s onwards.

OKB-115's next step in jet fighter development was the Yak-25 of 1947 – yet another straight-wing aircraft (the first to bear this designation; it was reused in 1950 as the service designation of the Yak-120 twin-engined swept-wing interceptor). As already mentioned, the Council of Ministers directive issued on 11th March 1947 tasked several design bureaux with developing new tactical fighters; specifically, the Yakovlev OKB was to create a straight-wing fighter powered by a single RR Derwent V. The 'straight-wing' clause was very probably included at the request of Aleksandr S. Yakovlev who was still wary of swept wings.

In designing the Yak-25 the engineers had, first of all, to eliminate the Yak-23's main deficiencies: the pod-and-boom arrangement (which was detrimental to flight performance) and the poor cockpit visibility caused by the aft position of the cockpit. Hence the Derwent V turbojet was relocated to the aft fuselage, while the pressurised cockpit equipped with a bulletproof windscreen and an ejection seat was placed in the forward fuselage between the engine's inlet ducts; this arrangement had been used by OKB-115 on the Yak-19. As on the latter type, the Yak-25's fuselage had a break point aft of the wings allowing the aft fuselage to be detached for engine maintenance or removal; the fuselage break was sealed by a wraparound duralumin strip. The fuselage was 8.66 m (28 ft 4.94 in.) long, with an almost circular section – 1.36 m (4 ft 5.54 in.) wide and 1.34 m (4 ft 4.75 in.) high; cross-section area was 1.4 m² (15.05 sq. ft).

For the first time in Soviet design practice, airbrakes were installed on the aft fuselage sides beneath the horizontal tail, deploying automatically when the aircraft approached never-exceed speed. Also, the Yak-25 was the first Soviet aircraft to feature an air conditioning system using engine bleed air; the system was designed by Yakovlev OKB engineer G. D. Protasov.

The Yak-25 had two-spar wings with a span of 8.88 m (29 ft 1.6 in.), an area of 14.0 m² (150.53 sq. ft) and a thickness/chord ratio of 9% throughout. Sweepback at quarter-chord was 2°45' but for all practical purposes the wings can be considered unswept; the aspect ratio was 5.64 and wing taper was 2.5. The straight-through wing spars were bent to a U-shape where they passed through the fuselage to avoid infringing on the inlet ducts; the centre section incorporated an abbreviated auxiliary spar (also U-shaped) to which the main landing gear units were attached. The spar flanges were made of steel T-beams and the spar webs of V-95 grade steel sheet. The Yak-25 utilised TsAGI laminar airfoils developed by Lab No. 1 chief G. P. Svischchev, ranging from S-9S-9 at the root to KV-4-9 at the tip. The wings featured TsAGI slotted flaps deflected 25° for take-off and 55° for landing.

The swept tail surfaces were of cruciform layout, as was customary for Soviet fighters at the time. The stabilizers were swept back 45° (though it is not clear whether this was leading-edge sweep or sweep at quarter-chord). Once again the vertical and horizontal tail were of two-spar construction and employed TsAGI laminar airfoils; stabilizer span was 3.208 m (10 ft 6.3 in.), vertical tail area was 2.125 m² (22.85 sq. ft) and horizontal tail area 3.0 m² (32.25 sq. ft).

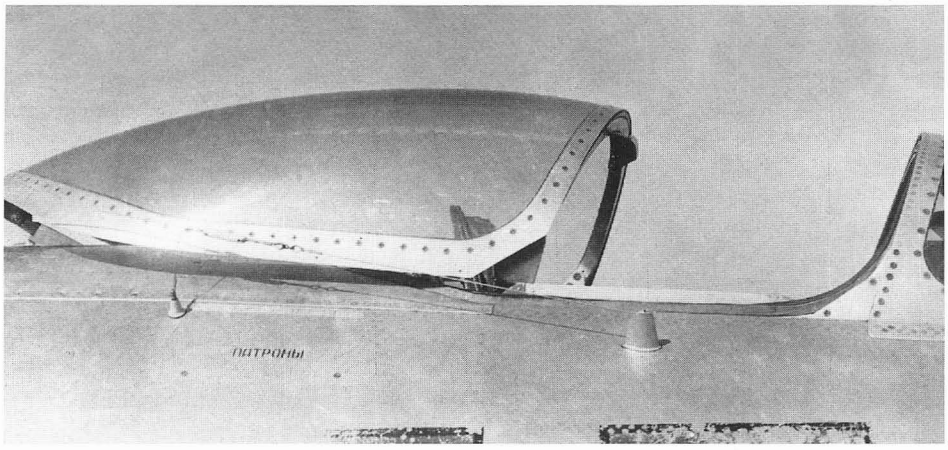
The tricycle landing gear was similar to that of the Yak-19, with a 400x150 mm (15.7x5.9 in.) nosewheel and 570x140 mm (22.44x5.51 in.) mainwheels. The armament was different, comprising three 23-mm (.90 calibre) Nudel'man/Rikhter NR-23 cannons with 75 rpg housed in the forward fuselage beneath the cockpit. To extend range the Yak-25 could be fitted with 380-litre (83.6 Imp. gal.) teardrop-shaped drop tanks carried under the wingtips, as on the Yak-19.

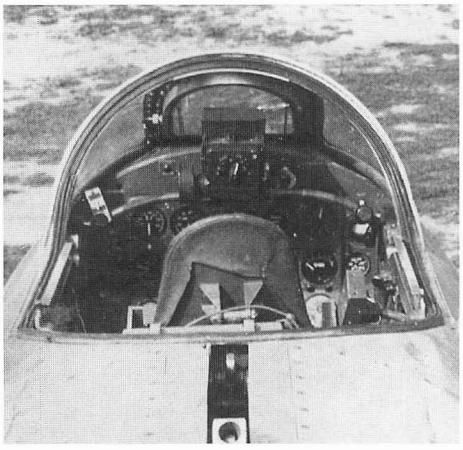
The avionics and equipment fit was updated to include an RSI-6M radio, an RPKO-10M direction finder, an SCh-3 IFF transponder, a more powerful GSK-1500 generator, a 12-A-10 DC battery, an S-13 gun camera and a KP-14 breathing apparatus with a 2-litre (0.44 Imp. gal.) oxygen bottle etc. As on the Yak-19, the pilot was protected by a 57-mm bulletproof windscreen, a 6-mm forward armour plate and an 8-mm armoured seat back; the GK NII VVS test report, however, states the bulletproof windscreen was 60 mm (2.36 in.) thick.

As already mentioned, the Yak-25 had a pressurised cockpit featuring a canopy jettison system. The original version was designed by Yakovlev's aide N. K. Skrzhinskiy and was a decidedly complex affair which could prove troublesome if fitted to a combat aircraft. Hence after discussing this cockpit (which had by then been almost completed at MMZ No. 115) with his colleagues Yak-25 project chief Leonid L. Selyakov proposed a simpler version; eventually Skrzhinskiy's cockpit was rejected and Selyakov's version was installed in the prototype aircraft.

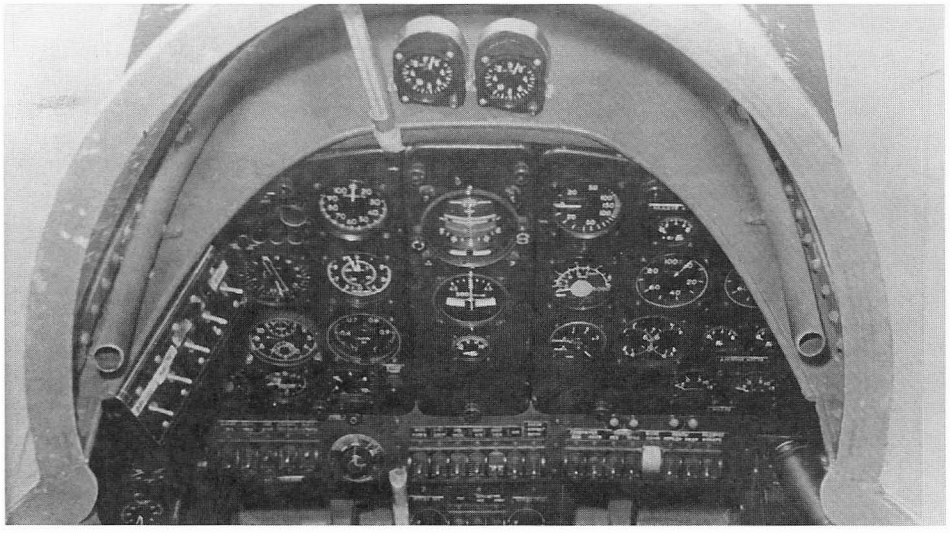
The 'step by step' approach taken by OKB-115 had its advantages; the trials of a new aircraft (with any changes that needed to be made in the course of the trials) and its eventual entry into full-scale production usually proceeded quickly and without a hitch. Yet there is always an exception to the rule, and the Yak-25 was one.

The design stage gave no reason for gloomy forebodings. The fighter was designed and built in an amazingly short time; A. S. Yakovlev approved the ADP project on 1st February 1947 and the first prototype (55 Yellow, c/n 115001 – ie, plant No. 115, 001st aircraft) was completed in October. As per OKB-115 custom, a yellow numeral (in this case, 2) was painted on the rudder; this numeral meant nothing at all and was intended to confuse would-be spies by falsely suggesting how many development aircraft had been built and in what order. In internal documents the aircraft was referred to as 'Yak-25 No. 01' for the sake of clarity.





Above left: The Yak-25's sliding canopy in fully open position. Note the wire aerial of the radio to the right of the cockpit.



Above: The cockpit of the third prototype Yak-25 with the sliding canopy portion removed; the track for the rear end of the canopy can be seen at the bottom of the picture.

Left: The instrument panel of the Yak-25, with a bank of switches below the flight and engine control instruments. Note the U-shaped windshield demisting air pipe.

On 29th October 55 Yellow was cleared for manufacturer's flight tests which officially began two days later. The ground test stage was extremely brief, and on 2nd November 1947 test pilot Sergey N. Anokhin took the first prototype Yak-25 into the air for the first time.

The tests showed that generally the Yak-25 outperformed its predecessors – the experimental Yak-19 and the production Yak-23. The fighter was easy to fly and handled well, performing the full range of aerobatic manoeuvres; importantly, it was absolutely spin-proof.

However, the first test flights brought unpleasant surprises as well. The laminar airfoils which worked well in the straight wings turned out to be absolutely unsuitable for the swept tail surfaces (or, to be precise, for the elevators). Anokhin discovered that severe buffeting set in at 500 km/h (270.27 kts) IAS, increasing dramatically as the speed grew; at 550 km/h (297.29 kts) IAS the pilot could no longer hold the control stick. Leonid L. Selyakov, who was Yak-25 project chief at the time, recalled that the buffeting was so bad that 'the pilot was thrown about, banging his head on the canopy, and all the needles of the flight instruments came off'.

In an effort to cure the problem a team of Yakovlev engineers supervised by M. A. Teitz studied piles of British and captured German materials on aerodynamics dealing with high-speed buffet and suggesting possible solutions. It transpired that because of the laminar airfoil with the maximum thickness well aft the elevators had large upwash and downwash angles, generating vortices which rocked the elevators up and down. The problem became especially acute when the elevators were deflected, as the vortices grew stronger and the oscillation frequency increased. The Germans and the British had tried to fix the problem (on the Messerschmitt Me 262 and the Gloster Meteor respectively) by riveting T-profiles or attaching heavy-gauge round wire along the trailing edges of the elevators and ailerons. This postponed the onset of buffeting but did not eliminate it completely; also, while the speed envelope was slightly expanded, elevator forces became excessively high with the T-profiles attached.

As a result, the first prototype Yak-25 was provisionally fitted with T-profiles 20 mm (0.78 in.) wide along the elevator trailing edges. (Yakovlev had had to resort to this earlier with the Yak-19, installing a T-profile on the rudder trailing edge.) The problem was ultimately solved by fitting the second and third prototypes with a redesigned horizontal tail. The new stabilizers employed the specially developed NACA 004 airfoil which had its maximum thickness at the chord line (the thickness/chord ratio was 20%); this made for very small upwash and downwash angles. Changes were also made to the vertical tail; outwardly this was could be seen by the recontoured fin cap.

The redesigned tail unit eliminated buffeting completely, enabling Anokhin to reach an unprecedented top speed of 982 km/h (530.8 kts) in one of the flights. (This is the figure quoted in the manufacturer's flight test report; other documents state a more modest but still impressive achievement of more than 970 km/h [524.3 kts]). During manufacturer's flight tests the empty weight was recorded as 2,285 kg (5,037 lb); take-off weight in 'clean' configuration was 3,235 kg (7,132 lb), increasing to 3,580 kg (7,892 lb) with drop tanks installed.

The story of the first fighter to bear the Yak-25 designation would be incomplete if details of individual aircraft identities and the Yakovlev OKB's counter-intelligence tricks were left out. Ironically, these tricks aimed at the 'potential adversary' proved so effective that they fooled many Soviet/Russian aviation

researchers, including the late Vadim B. Shavrov whose authority as an aviation historian is universally acknowledged. For many years it was erroneously believed that only two 'first-generation' Yak-25s (serialled 55 Yellow and 15 Yellow) were ever built; in fact, as already mentioned, there were *three* flying prototypes. The key to this puzzle is that the first prototype (c/n 115001, referred to in paperwork as 'aircraft No. 01') was serialled 55 Yellow and marked '2 Yellow' on the rudder. The second aircraft (c/n 115002 or 'aircraft No. 02') was indeed serialled 15 Yellow and likewise had a yellow numeral '2' on the rudder, while the third Yak-25 (c/n 115003 or 'aircraft No. 03') was *again serialled 55 Yellow and marked '2 Yellow'!*

The trick was disclosed when high-quality pictures of the three prototypes showing the c/n clearly stencilled on the fin became available. However, even if the c/n cannot be read on the photo, the first and third prototypes differ visibly in vertical tail shape, the latter aircraft having a more angular fin cap.

The attempts to cure the fighter's pitch control problem coincided with the preparations for the annual Tushino flypast. In August 1948 Sergey N. Anokhin was to lead the parade in the Yak-25 (he was even allocated the callsign ***Par**oos*, 'Sail', in advance). The aircraft was to pass in front of the grandstand with the Soviet government and Communist Party leaders at 100 m (328 ft), doing 500 km/h (270.27 kts). Leonid L. Selyakov recalls that he was summoned to the KGB shortly before the show; after asking a few questions about the flypast the KGB officer demanded a written statement that the demonstration would be perfectly safe. Selyakov wrote and signed the required statement without hesitation and the Yak-25 put on a spectacular performance at Tushino – just like the Yak-19 had done a year earlier. Curiously, Aleksandr S. Yakovlev chose not to intervene before the show; afterwards, however, he summoned Selyakov and inquired on what grounds the latter had ventured to give such guarantees (it is easy to guess the consequences, had the aircraft crashed, especially with fatalities on the ground!). Selyakov replied earnestly that technically there was no risk – and should anything go wrong, he had counted on Yakovlev (who was still influential then) to step in and save him. This last bit, Selyakov says, 'amused Yakovlev immensely'. (It is easy to see why. In those days retribution came swiftly, starting with those at the top of the pile; Yakovlev would hardly have been able to save himself, much less save others!)

Because of the abovementioned problems and modifications the manufacturer's flight test programme dragged on until mid-1948; the test report was finally signed on 3rd July. This in turn caused the State acceptance trials to be postponed; besides, GK NII VVS encountered difficulties in filling out the associated paperwork because the Yak-25 was the first Soviet aircraft to feature a fully capable pressurised cockpit.

The cockpit was pressurised at 0.3 kg/cm² (4.28 psi). The engineers had to prove that if the canopy jettison system failed the pilot would manage to jettison the canopy manually in order to eject. OKB-115 had already had some negative experience with the Yak-19; as recounted earlier, trials of canopy jettison system were dangerous for aircraft and pilot alike.

Selyakov suggested a different *modus operandi* – the system was to be tested on the ground. One Sunday when the territory of MMZ No. 115 was almost empty he ordered the Yak-25 prototype wheeled into the assembly shop, then climbed into the cockpit, strapped himself in and closed the canopy. When the nominal pressure differential of 0.3 kg/cm² had been attained, using a ground compressor, Selyakov jettisoned the canopy, with an Air Force commission watching. He did not feel too well immediately afterwards because of the decompression, but it was worth the suffering: the military were convinced by the demonstration and signed a protocol to the effect that the cockpit and canopy jettison system were OK. Selyakov later wrote he was confident that everything would work; after all, he had designed the system himself. Besides, the canopy and the jettison system had been manufactured and tested under his personal supervision.

Another unpleasant surprise (fortunately, again with no disastrous consequences) occurred during the manufacturer's flight tests. Sergey N. Anokhin had test flown the MiG-9 before transitioning to the Yak-25, and it took a while for him to get used to the latter's slightly different cockpit layout. Standardised cockpits were still unheard-of in those days, and the different location of certain control levers nearly resulted in a major accident. The port control console of early Soviet jet fighters featured the throttle, the engine shutdown lever and the airbrake control lever. These were located differently on the MiG-9 and the Yak-25 (left to right: throttle, shutdown lever and airbrake control on one aircraft and throttle, airbrake control and shutdown lever on the other). Attempting to deploy the airbrakes in one of the flights, Anokhin grabbed the wrong lever and shut down the engine instead. The aircraft was at low altitude, which left no time to try to restart the engine, and the pilot did the only possible thing, landing across the runway. Luckily, both he and the aircraft stayed in one piece.

On 12th June 1948 the Council of Ministers issued directive No. 2052-804ss which, among other things, gave a more specific operational requirement concerning the Yak-25 and demanded that the fighter be submitted for State acceptance trials. On 5th July Vice Minister of Aircraft Industry Shishkin signed the appropriate papers, authorising the aircraft to be transferred to GK NII VVS. Next day a LII test pilot ferried the third prototype to Chkalovskaya AB, a complete set of documents following three days later.

The Act of acceptance (stating that the aircraft had begun State acceptance trials) said that the fighter had been delivered with an incomplete avionics and equipment fit. Missing items included the RSI-6 communications radio, the Bariy-1 (Barium) IFF transponder, the NI-46 navigation display (*navigatsi**on**nyy indi**kah**tor*), the gun camera, the fire extinguishing system etc.; additionally, a 2-litre (0.44 Imp. gal.) oxygen bottle was fitted instead of the specified 4-litre (0.88 Imp. gal.) bottle. Moreover, the manufacturer's flight tests the Yak-25 had not included several important aspects. Among other things, the fighter's behaviour in maximum-speed flight at altitudes below 2,000 m (6,561 ft) had not been studied and the canopy jettison system was not tested in flight. Likewise, nobody had tried restarting the engine after an in-flight shutdown or studied the effect of firing the cannons on engine operation above 3,000 m (9,842 ft); the fighter's ability to withstand the specified maximum operational G loads had not been verified, and so on. Finally, some of the features requested by the military had not been incorporated; for instance, the ammunition supply was only 75 rpg instead of the required 100 rpg, there was no wire mesh screen in the inlet duct to protect the engine from foreign object damage (FOD), the mechanical canopy jettison system was inoperative etc.

Still, the VVS agreed to hold State acceptance trials of the Yak-25; the formal Act of acceptance was signed on 29th July. For the reasons stated above it was decided to abbreviate the trials programme, limiting it to the bare necessities; still, there was really no point in holding these trials because other fighter types had entered production in the meantime.

Officially State acceptance trials of Yak-25 No. 03 lasted from 23rd July to 9th September 1948. As was the case with the Yak-19, Lt. Col. A. G. Proshakov was project test pilot and Capt. V. P. Belodedenko was the engineer in charge of the tests. The fighter fully met the specifications to which it was designed, and despite an all-up weight 270 kg (595 lb) higher than that of the Yak-23 it was markedly superior to the latter aircraft in speed and service ceiling. The trials showed that by dispensing with the pod-and-boom arrangement the engineers succeeded in increasing speed by 25-50 km/h (13.5-27.0 kts) as compared to

Upon completion of the flight test programme the second prototype Yak-25 was converted for testing the Burlaki towed fighter concept. The object atop the air intake looking like a refuelling probe is actually a telescopic 'harpoon' for hooking the fighter up to the bomber it was to protect.

the Yak-23, depending on the altitude; the Yak-25 had a top speed of 950 km/h (513.5 kts) at sea level and 972 km/h (525.4 kts) at 3,000 m (9,842 ft). The fighter climbed to 5,000 m (16,404 ft) in 2.6 minutes versus 2.3 minutes for the lighter Yak-23; on the other hand, the service ceiling was 15,200 m (49,868 ft) or 400 m (1,312 ft) higher than the Yak-23's. At 5,000 m the Yak-25 could make a 360° turn in 29 seconds. The take-off run was only 540 m (1,771 ft) and the landing run 500 m (1,640 ft). Maximum range with drop tanks at 10,000 m (32,808 ft) was 1,445 km (897.5 miles) – 140 km (87 miles) less that the Yak-23's, while endurance (as per manufacturer's flight test report) was 2 hours 16 minutes.

As already mentioned, the canopy jettison system could not be tested during the State acceptance trials, so a separate flight test programme was held afterwards for this purpose (the test report was signed on 29th September 1948). The system worked as it should; the problem that affected the Yak-19 was not repeated.

The tests of the straight-wing Yak-25 held in 1948 were no more than a formality; the 'step by step' development policy had backfired on the Yakovlev OKB in this instance. While the design staff of OKB-115 methodically refined the straight-wing jet fighter concept from the Yak-15 to the Yak-25, the rival OKB-155 headed by Artyom I. Mikoyan brought out and put into production the highly successful swept-wing MiG-15 fighter which surpassed the Yak-25 in many respects. (Interestingly, the Yak-25 reached a top speed of Mach 0.85 at 1,000 m (3,280 ft), which was just a trifle slower than the MiG-15's Mach 0.902.) Thus Yakovlev finally had to concede it was time to switch to swept-wing designs; therefore, even as the State acceptance trials proceeded, all further attempts to improve the Yak-25 were abandoned.

However, this was not yet the end of the road for the Yak-25. Two of the prototypes were later used for test and development purposes. The second aircraft was modified under the *Burlaki* (pronounced *boorla**kee***) captive escort fighter programme. To this end a pneumatically-operated telescopic probe with a barbed tip was installed atop the nose; this probe (promptly dubbed 'harpoon') would lock into a drogue at the end of a steel cable paid out by the bomber to be escorted. (In 18th century Russia the *burlaki* were teams of strongmen hauling barges up rivers by means of ropes, hence the name of the programme.) After connecting to the bomber the fighter pilot would shut down the engine to save fuel for an eventual dogfight, restarting the engine and disengaging from the 'mother ship' when enemy fighters appeared.

Initial tests of the *Burlaki* system were successful as far as the procedure of approaching and engaging the drogue was concerned. However, when it came to operational suitability of the concept, using five suitably modified MiG-15*bis* *Fagot-Bs* and Tupolev Tu-4 bombers, the system failed dismally; paraphrasing the system's 'strongman' name, the *Burlaki* turned out to be strong in the arm but weak in the head. The time required to start up, disengage from the bomber and repel the attackers was so great that the bomber would more than likely be shot down, taking its captive protectors with it, before they even had a chance to join the fray. Besides, the drag created by the towed fighters slowed down the bomber, which inevitably slowed down the entire bomber formation. Finally, with the engine shut down, the cockpit heating system was inoperative and the fighter pilot froze miserably at high altitude. Thus, the *Burlaki* system failed to pass State acceptance trials and was abandoned.

In another research programme the third (or first?) Yak-25 prototype was fitted experimentally with a non-retractable bicycle landing gear. Presumably this was associated with the development of the aforementioned Yak-120 (Yak-25 *Flashlight-A*) interceptor and the family of twinjet tactical aircraft derived from it. all of which had a bicycle landing gear. These lie outside the scope of this book, but are covered in the companion Aerofax volume *Yakovlev Yak-25/-26/-27/-28 – Yakovlev's Tactical Twinjets,* also published by Midland Publishing.

Afterwards, A. S. Yakovlev developed a number of single-engined swept-wing light fighters – the Yak-30 (essentially a swept-wing Yak-25), Yak-50 and several others. The Yak-50 possessed excellent performance in its day, but fortune had turned against Yakovlev in this area; the MiG-17, which had entered large-scale production, became the mainstay of the Soviet fighter force in the 1960s.

Chapter 4

Lavochkin's First Jets

As was the case with the other Soviet 'fighter makers', OKB-301 headed by Semyon Alekseyevich Lavochkin took its first steps in jet fighter development when the Great Patriotic War was still raging. In 1942 the designer Mikhail I. Goodkov, who had previously teamed with Lavochkin to create the LaGG-3 fighter, proposed designing a jet fighter around Arkhip M. Lyul'ka's RD-1 turbojet rated at 500 kgp (1,102 lb st). The project was reviewed by the Council of People's Commissars – and rejected for the simple reason that no practical jet engine was available yet. As recounted earlier, Lyul'ka could not resume his work on jet engines interrupted by the outbreak of the war until 1944 when he was able to start development of the 1,250-kgp (2,755-lb st) S-18 turbojet at the newly-founded institute. By then, however, it was too late for Goodkov whose OKB had been disbanded in the meantime. Thus, the task of developing a fighter around Lyul'ka's new engine was passed on to the Lavochkin OKB pursuant to a CoPC directive issued in May 1944; this document stated a flight test commencement deadline of March 1946.

Provisionally designated La-VRD (for *voz-**doosh**no-reak**tiv**nyy **dvig**atel'* – lit. 'air reaction engine', ie, turbojet), the fighter was developed by the Lavochkin OKB's Moscow division located at the premises of aircraft factory No. 81. (The reference to 'air' means the oxidiser; this is because liquid-fuel rocket engines are referred to by the acronym ZhRD – ***zhid**kostnyy reak**tiv**nyy **dvig**atel'*, the ***zhid**kost'* (liquid) referring to the liquid oxidiser.) Lavochkin's closest aide (First Deputy Chief Designer) Semyon M. Alekseyev supervised the actual design effort, which had a considerable influence on the fighter's appearance. Alekseyev utilised the twin-boom layout to which he had taken a liking; he had used it earlier for a whole series of fighter projects employing piston engines with tractor or pusher propellers. This time, however, he also heeded TsAGI's recommendations concerning high-speed aircraft design.

The La-VRD featured shoulder-mounted wings, lateral air intakes, twin fins and a tricycle undercarriage. The S-18 turbojet was buried in the short and stocky fuselage behind the cockpit. The horizontal tail linking the fins was placed a little higher than the wings in order to keep it well above the jet efflux. The armament comprised two 23-mm (.90 calibre) cannons with 60 rpg housed in the tailbooms. The use of lateral intakes and the need to minimise the fuselage cross-section area forced the engineers to make the cockpit rather narrow.

According to preliminary calculations, the 1,250-kgp thrust of the S-18 would enable the fighter to reach a top speed of 890 km/h (481 kts) at sea level and 850 km/h (459.45 kts) at 5,000 m (16,404 ft). The fighter was to climb to 5,000 m in 2.5 minutes and have a service ceiling of 15,000 m (49,212 ft). More detailed specifications are given in the following table.

Length overall	9.00 m (29 ft 6.33 in.)
Height on ground	2.7 m (8 ft 10.3 in.)
Wing span	9.8 m (32 ft 1.82 in.)
Wing area, m^2 (sq. ft)	15.0 (161.29)
Vertical tail area, m^2 (sq. ft)	1.72 (18.49)
Horizontal tail area, m^2 (sq. ft)	2.72 (29.24)
Empty weight, kg (lb)	2,640 (5,820)
Normal all-up weight, kg (lb)	3,300 (7,275)
Fuel load, kg (lb)	500 (1,102)
Top speed, km/h (kts):	at sea level
at 5,000 m (16,404 ft)	890 (481.0)
850 (459.45)	
Climb time to at 5,000 m, minutes	2.5
Service ceiling, m (ft)	15,000 (49,212)
Range in maximum-speed flight at S/L, km (miles)	140 (86.9)
Endurance in economic cruise mode, minutes	55
Armament	2 x 23-mm cannons, 60 rpg

The S-18 was ready for bench testing by the end of 1944; the test programme was completed in 1945, leading to the decision to develop a flight-cleared version and manufacture a small development batch thereof. This meant no engine was available immediately to power the La-VRD, and the project was put on hold.

After moving back to Moscow from evacuation and rejoining the Moscow branch based at aircraft factory No. 81 the Lavochkin OKB set about developing a new jet fighter in February-March 1945. As distinct from the La-VRD project, the OKB was now facing competition from other design bureaux, as the specification for a jet fighter had been issued to several OKBs at once.

Bolstering the reunited design team with the personnel of the Moscow branch speeded up the design work appreciably. The new fighter was designed around the Junkers Jumo 004B turbojet, thus the main task facing the engineers was to obtain a high top speed and good field performance in spite of the engine's rather limited thrust. In April 1945, just a month or two after the work was started, the OKB came up with two projects – **'aircraft 150'** (aka *izdeliye* 150), a lightweight single-engined fighter, and the heavy twin-engined **'aircraft 160'** (*izdeliye* 160; the first Lavochkin aircraft to have this designation).

The second project was an insurance policy in case the '150' turned out to be a lemon – as it very probably would, since the 900 kgp (1,984 lb st) delivered by a single Jumo 004B might not be enough to achieve the required performance. This, incidentally, forced the engineers to reduce the fuel load and armament to an absolute minimum, which of course was detrimental to the fighter's combat potential. Besides, the choice of a twin-engined layout for the '160' was inevitably influenced by the Me 262 and the Gloster Meteor. There was one more reason for this parallel development. As already mentioned, Alekseyev had a predilection towards heavy fighters with potent armament and a large fuel capacity; it was probably he who insisted that the 'heavy' 'aircraft 160' be developed.

Strictly speaking, 'aircraft 160' could hardly be termed a heavy fighter, considering its design all-up weight was only 4,020 kg (8,862 lb) versus 6,500-7,000 kg (14,330-15,432 lb) in the case of the German and British fighters. The aircraft's design was optimised for its intended principal role of intercepting and destroying heavy bombers. The armament consisted of three 23-mm Nudel'man/Sooranov NS-23 cannons with 80 rpg housed in the fuselage nose. The '160' had a tailwheel undercarriage and a pressurised

The first 'aircraft 150' completed by plant No. 381. It underwent a few changes before being flown.

cockpit with armour protection. The extremely large fuel load (1,223 kg/2,696 lb) provided a long endurance. According to project specifications, top speed at 5,000 m (16,404 ft) was to be 850 km/h (459.45 kts); cruising at this speed at 4,000 m (13,123 ft), the fighter was to stay airborne for 30 minutes. The aircraft was 10.2 m (33 ft 5.57 in.) long and 2.7 m (8 ft 10.3 in.) high, with a wing span of 11.0 m (36 ft 1.07 in.) and a wing area of 20.2 m² (217.2 sq. ft); vertical tail area and horizontal tail area were 1.84 m² (19.78 sq. ft) and 3.42 m² (36.77 sq. ft) respectively.

Still, even the augmented design team was not in a position to develop two jet fighters at once. Realising this, S. A. Lavochkin acted very rationally; taking advantage of the fact that Alekseyev had been appointed head of the OKB of plant No. 21 (at his recommendation, mind you), Lavochkin shelved the 'aircraft 160' project as soon as Alekseyev left for Gor'kiy to take over his new job, concentrating available resources on the 'aircraft 150'. In turn, Alekseyev pursued the twinjet fighter subject on his own after coming to Gor'kiy.

As was the case with the La-VRD, the engineers relied on TsAGI's latest recommendations in selecting the new single-engined fighter's general arrangement. The aircraft was of all-metal construction, featuring one-piece shoulder-mounted unswept wings with an area of 12.15 m² (130.64 sq. ft). The relatively short fuselage was of pod-and-boom design, the slender aft fuselage carrying cruciform tail surfaces. The cockpit was located well forward, offering the pilot a good field of view; it was enclosed by a three-piece teardrop canopy, the centre portion opening to starboard and the fixed rear portion being attached to a maintenance hatch cover. The fixed windscreen incorporated a 60-mm (2.36-in.) bulletproof windshield and the pilot was also protected by an 8-mm (0.31-in.) forward armour plate, 4-mm (0.15-in.) lateral armour plates and a 16-mm (0.63-in.) armoured headrest.

The Jumo 004B turbojet was located immediately aft of the cockpit so that the engine axis was at 3° to the fuselage waterline. To protect the duralumin skin from the jet exhaust a heat shield made of 1.5-mm (0.59-in.) steel sheet was attached to the aft fuselage underside, with a small gap in between allowing cooling air to pass. Fuel was carried in five integral tanks of complex shape in the fuselage surrounding the engine bay and in two bladder tanks housed in the wing centre section; the designers believed this would provide adequate range and endurance.

The hydraulically retractable tricycle landing gear had a 400x150 mm (15.74x5.9 in.) nosewheel and 650x180 mm (25.59x7.08 in.) mainwheels. All three units retracted into the fuselage, which resulted in a very narrow track of only 1.82 m (5 ft 11.6 in.); the wheelbase was 2.7 m (8 ft 10.3 in.) or 2.615 m (8 ft 6.95 in.) in no-load condition. On the ground the fighter sat at a 4°36' nose-up angle.

The fighter was armed with two NS-23 cannons with 75 rpg. The avionics and equipment suite included a radio set with an RSI-6 transmitter and RSI-6M receiver, an RPKO-10M DF, an SCh-3 IFF transponder, a gun camera, a GSK-1500 DC generator, a 12-A-10 DC battery and a KP-14 breathing apparatus with a 4-litre (0.88 Imp. gal.) oxygen bottle (a KP-12 breathing apparatus was used during manufacturer's flight tests).

Some of the design features incorporated into 'aircraft 150' were later used by the Lavochkin OKB in designing other fighters.

The advanced development project (ADP) stage was completed in April 1945 and in May the OKB set to work preparing the manufacturing drawings. During that same month aircraft factory No. 81 began construction of a full-scale mock-up which was completed in early June; this factory also manufactured several wind tunnel models to be used for development work at TsAGI.

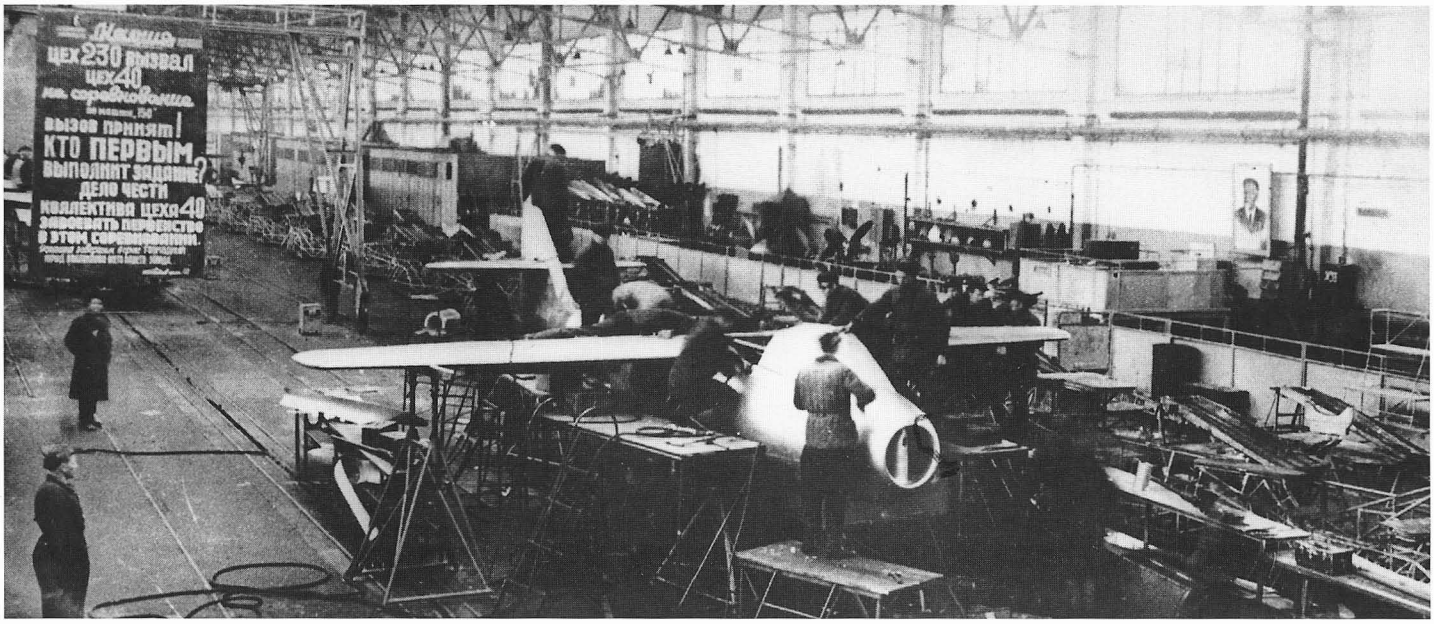
As already mentioned, in the early post-war years the Soviet aircraft industry continued operating, as it were, in wartime conditions, working at a slam-bang rate. As early as August 1945 another Moscow-based aircraft factory, No. 381, which was completing production of piston-engined fighters, started manufacturing a development batch of five 'aircraft 150' fighters. The Soviet copy of the Jumo 004B intended to power the fighter had entered production in the meantime as the RD-10; hence the aircraft was sometimes referred to in NKAP (later MAP) documents as the 'I-150 powered by the RD-10 engine'. An extremely tight schedule was imposed on the plant: the first aircraft was to be completed by 1st November, the next two by the end of the month and the final two in December 1945.

The choice of a different factory to build the pre-production batch was dictated by the limited capacity of plant No. 81. At the end of August 1945 the OKB of plant No. 81 delivered a complete set of manufacturing drawings to plant No. 381; however, the latter enterprise took extremely long to gear up for production, the five fighters taking almost a full year to build. The reason was that, until then plant No. 381 had built strictly aircraft of wooden construction and lacked the tooling for manufacturing all-metal airframes, unlike Lavochkin's experimental shop. (The experimental plants of Yakovlev's OKB-115 and Mikoyan's OKB-155, on whose territory the respective design bureaux were located, were clearly better off in this respect, since they had the required tooling and were directly controlled by Aleksandr S. Yakovlev and Artyom I. Mikoyan.) Besides, the workforce and production engineers of plant No. 381 lacked the necessary skills, and mastering new technologies within a brief period was a major challenge for them.

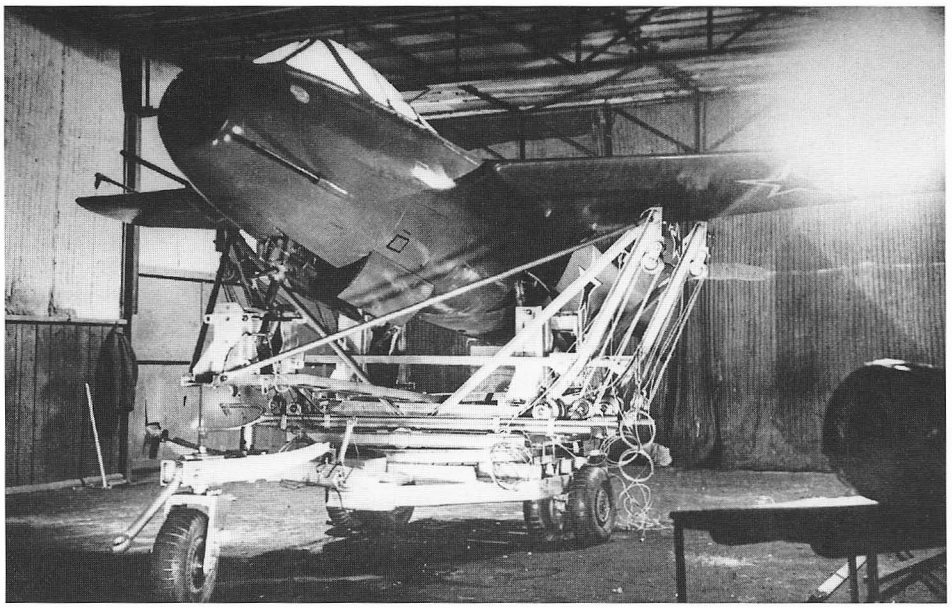
In October 1945 the Lavochkin design bureau was obliged to move once more. This time the OKB together with plant No. 81 was transferred to aircraft factory No. 301 in Khimki, just outside Moscow's northern limits, pursuant to an NKAP ruling of 2nd October; the purpose of this move was to expand the OKB's production facilities. Thus, S. A. Lavochkin had run full circle, coming back to the place where he had started his career as Chief Designer six years earlier. Not only were the capabilities of plant No. 301 enhanced by this amalgamation but Lavochkin was able to build his fighter prototypes there.

Nevertheless, construction of the 'aircraft 150' prototypes at plant No. 381 had fallen way behind schedule. On 26th November 1945 the plant's director and chief engineer were summoned to an NKAP briefing and chewed out. The briefing (the subject of which was jet fighter production) was attended by Vice People's Commissars of Aircraft Industry Dement'yev and Voronin, Chief Designers Yakovlev, Mikoyan and Lavochkin and the directors of several production factories.

Still, this dressing-down did little to speed up the work. All that plant No. 381 managed by the end of the year was to complete a static



Above: Assembly of an initial-production batch of 'aircraft 150' fighters at the Gor'kiy aircraft factory No. 21 in the autumn of 1946. The placard on the left reads, *'Urgent! Shop 230 has challenged Shop 40 to a competition with regard to production of* izdeliye *150. The challenge has been accepted! Who will be the first to complete the task? It is a matter of honour for the workforce of Shop 40 to win this competition.'*



Right: Since the 150's wings were built integrally with the fuselage, delivering the '150s' to Moscow for trials turned into a major problem. A special trailer had to be designed for transporting the fighters by road.

Below: ZiS-5V lorries tow production 'aircraft 150' fighters along the Gor'kiy-Moscow highway. The trailer-mounted aircraft made pretty much a hair-raising picture, though it is doubtful that many were able to see it due to security measures.

Above: The first 'aircraft 150' completed in Gor'kiy (21 Red, c/n 210101) at NII VVS. Mote the factory's badge on the nose and tail.

test airframe of 'aircraft 150'. This promptly failed during tests – the rear fuselage was not strong enough; it turned out that the main gear attachment fittings integrated into the fuselage structure had been made of unhardened steel. The tests had to be repeated after this defect had been eliminated. At the same time the engineers reinforced the wings and tail unit to meet the new structural strength requirements, increasing the vertical tail area in so doing.

All in all the static tests, ensuing modifications and renewed tests (all of which were performed at plant No. 301) lasted six months; it was not until July 1946 that the first flying prototype had been modified accordingly. All subsequent 'aircraft 150' airframes were built to the new standard; it is noteworthy that plant No. 381 completed only three of the five prototypes, turning over the components of the other two aircraft over to plant No. 301 for assembly.

On 1st August 1946 the now-Ministry of Aircraft Industry gave the go-ahead for the fighter's first flight; however, it was a few more weeks before the first prototype could be flown. Suffice it to say that the engine had to be replaced twice during the ground test stage. On 26th August the '150' was delivered to LII; the manufacturer's flight tests officially began on the following day. However, the first high-speed taxi runs on 30th August revealed a CG problem; the aircraft rotated at just 100-110 km/h (54-59 kts), the aft fuselage scraping along the runway. Ballast had to be installed in the forward fuselage to move the CG forward. Finally, on 11th September 1946 the fighter performed its maiden flight with factory test pilot A. A. Popov at the controls.

On 12th September 1946 the Soviet Council of Ministers let loose with yet another directive, requiring the Ministry of Aircraft Industry to accept, test-fly and demonstrate small batches of new jet fighters (eight to fifteen aircraft of each type) by 7th November. On that day the aircraft were to participate in the traditional military parade in Moscow's Red Square marking the anniversary of the October Revolution. In compliance with this directive two plants (No. 301 in Khimki and No. 21 in Gor'kiy) completed an initial production batch of eight 'aircraft 150' fighters, including the first prototype (later the type was allocated the unofficial service designation **La-13**). Six of these aircraft were to participate in the flypast over the Red Square, while the other two were standby aircraft in case one of the machines 'went tech'.

As already mentioned, the Khimki aircraft factory merely assembled the aircraft from

33 red, another 'aircraft 150' of the initial-production batch, seen during manufacturer's flight tests in the winter of 1946-47

available components, picking up where plant No. 381 had left off; conversely, the Gor'kiy factory had to build the fighters from scratch. The Lavochkin OKB urgently delivered the drawings of the first prototype to plant No. 21, sending a team of engineers to aid in launching production. Even so, the government's deadline was absolutely unrealistic; still, the Gor'kiy factory achieved this Mission Impossible, tooling up for production in just five to ten days and completing the first aircraft in only a week and a half.

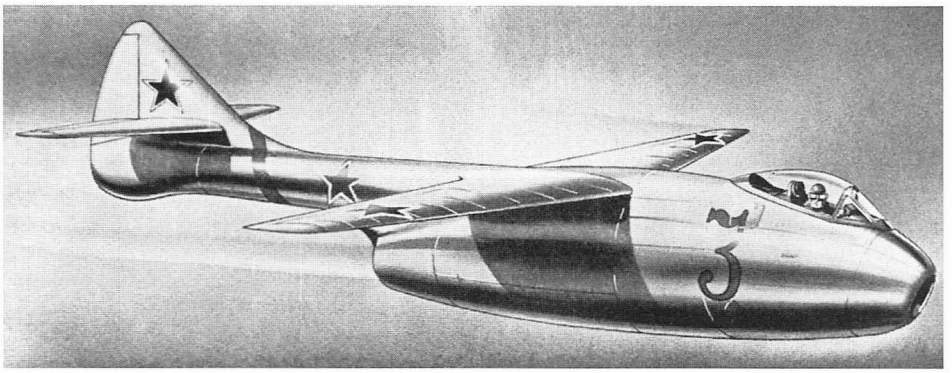
Thus, by 1st November all eight examples had been tested by both LII and GK NII VVS; after making 67 training flights singly and in various formations the Air Force's test pilots reported the aircraft was fit to perform at the 7th November parade. As had been the case with the first Yak-15s, the Lavochkin '150' fighters taking part in the parade lacked some equipment items, including cockpit armour, ammunition boxes and oxygen equipment; to preserve the CG position these were substituted with 75 kg (165 lb) of ballast. At least two aircraft had serials – 21 Red (the first Gor'kiy-built example, c/n 210101) and 33 Red.

Interestingly, flying the jets earmarked for the parade from Gor'kiy to Moscow was considered too risky, and an immediate problem arose. The '150' had one-piece wings built integrally with the fuselage, which rendered transportation by rail impossible; the fighters were delivered to Moscow by road on custom-built three-wheel trailers.

The parade forced an interruption of the trials programme, since the fighters had to be turned over to the Air Force for evaluation and familiarization training. Early test flights of the first prototype revealed that the wheel well doors tended to open uncommandedly at about 650 km/h (351 kts) IAS due to boundary layer suction and were not rigid enough; hence the indicated airspeed of the aircraft slated to fly over the Red Square was limited to 600 km/h (324 kts) and the G load to 3 Gs.

Eventually, however, the flypast had to be cancelled; on 7th November the weather in Moscow turned sour, with rain, snow and heavy icing, and all aircraft involved in the flypast were ordered to return to base. The public at large had to wait another six months to see Lavochkin's new fighter which was unveiled during the 1947 May Day parade.

Still, the effort was not in vain; the preparations for the would-have-been parade performance gave the leaders of the Soviet Air Force and MAP some ideas as to which of the fighter prototypes were best suited for production and service. The '150' was not among the winners: the military discovered numerous design flaws and manufacturing defects which were duly recorded in a special 'pre-parade evaluation' report. These included poor directional stability, a cramped cockpit lacking heating and ventilation, difficult access to the engine and its systems (especially the Riedel two-stroke starter which frequently failed and hence was the subject of constant attention for the ground crews). Landing was fraught with danger because the stick forces from the elevators were too small – the pilot did not 'feel' the aircraft and it was all too easy to give excessive elevator input. The fuel capacity was inadequate; to add offence to injury a significant amount of fuel (up to 32 litres/7.04 Imp. gal.) could not be



Above: An early artist's impression of the '150' published in *Jane's All the World's Aircraft*.

Above: An 'aircraft 150' built by the Moscow aircraft factory No. 381.

Another view of the same aircraft; note the curved windshield minus bulletproof windscreen and the absence of the tail bumper.

used up, and there was no fuel meter! Lastly, the Air Force was unhappy with the aircraft's limited armament comprising only two 23-mm cannons.

The fighter's fate now depended on the results of the State acceptance trials; before these could begin, however, the '150' had to be upgraded to suit the Air Force's demands. Five of the prototypes were returned to plant No. 301 for modifications; three of them rejoined the test programme in the autumn of 1946. The manufacturer's flight tests (performed by factory test pilot I. Ye. Fyodorov together with LII test pilots Mark L. Gallai and Gheorgiy M. Shiyanov) were completed on 27th April 1947. One of the abovementioned three aircraft served for performance testing (measuring the top speed at various altitudes etc.); another was used for determining the fuel consumption and range, while the third was used to check the stability and handling characteristics. The test were a protracted affair, mainly due to bad weather with heavy snowfalls; the runway in Zhukovskiy was covered with snow most of the time, and the snowploughs could not cope with it.

The stability and handling tests gave a complete picture of the fighter's behaviour, the main shortcomings being excessive lateral stability and too low stick forces in the pitch control channel. These could be cured by angling the wingtips downwards and reducing the elevators' aerodynamic balances. The landing gear emergency extension system had to be modified, too, and the wheel well doors reinforced, as there were cases of them opening or even breaking away in flight.

The chief source of annoyance, however, was the powerplant. On the first prototype four engine changes had to be made in the course of the tests, and each engine differed substantially in ground and flight thrust rating, which complicated the measuring of the aircraft's top speed and rate of climb. Initial production RD-10s were plagued by unreliable operation of the engine control system. In winter, when the engine speed was changed during ground runs, the engine oil temperature did not exceed +30°C (+86°F); as the aircraft climbed, however, the temperature rose to +80°C (+176°F), causing the engine rpm and hence the thrust to drop. With the first engine the aircraft was 80-100 km/h (43-54 kts) slower than anticipated; after the first engine change the shortfall was reduced to 50-70 km/h (27-38 kts), but still, there it was. Only when the third engine was fitted did the aircraft meet the specified top speed figures.

The performance eventually obtained at the manufacturer's flight tests was this: top speed was 878 km/h (474.59 kts) at 4,200 m (13,779 ft) and 850 km/h (459.45 kts) at 8,240 m (27,034 ft); the fighter climbed to 5,000 m (16,404 ft) in 4.8 minutes and the service ceiling was 12,600 m (41,338 ft). By the end of April 1947 the eight aircraft had made 115 flights between them, including 48 as part of the actual test programme. All in all, the '150' was flown by 14 Air Force pilots, three factory test pilots and three LII test pilots.

In March 1947, when the manufacturer's flight tests were still in progress, GK NII VVS held a special test programme to determine the air pollution level in the cockpit, using one of the 'aircraft 150' prototypes transferred to the institute for evaluation. The reason was that first-generation Soviet jet fighters had a common problem: fuel and oil leaked onto the engine during refuelling, subsequently decomposing when the engine casing got hot; as a result, smoke and fumes penetrated into the cockpit, irritating the pilot's eyes.

To solve the problem the engineers provided the '150' with both blow-in gills (on the main gear doors) and exhaust gills; their combined effect was to create a pressure differential, the resulting airflow through the engine bay removing the smoke and fumes. Additionally, the cockpit was separated from the engine bay by a hermetically sealed bulkhead; this was a major advantage over the Yak-15 (Yakovlev OKB engineers found it much harder to seal off the cockpit on this aircraft). Comparative testing at GK NII VVS showed that the cockpit of the Lavochkin fighter was filled with a much cleaner air.

An MAP order titled 'On the preparation of aircraft for the 18th August 1947 flypast' was issued in the spring of 1947. Among other things it required Chief Designer and Director of plant No. 301 Lavochkin to *'...prepare three 'aircraft 150' fighters with RD-10 engines and deliver them to GK NII VVS for testing in June or July.'* However, the aircraft could not be submitted for State acceptance trials until the deficiencies noted earlier (first of all the stability and handling problems) had been eliminated.

Hence a number of important changes was incorporated into one of the existing aircraft. The fuel capacity was increased from 597 to 780 litres (131.34 to 171.6 Imp. gal.). The wings were remanufactured as a separate assembly which could be detached from the fuselage, and the wingtips were angled 35° downwards. The elevators' aerodynamic balancing was reduced from 24% to 20%. The cockpit width was increased by 80 mm (3.15 in.) and the canopy rede-signed accordingly; importantly, the cockpit now featured an ejection seat, and the intended front and rear armour plates were finally installed.

Other changes concerned the equipment. A new radio aerial mast was installed and the instrument panel layout was changed. The DC battery and oxygen bottle were relocated to the forward fuselage. Finally, the existing maintenance hatch was widened and a second maintenance hatch was added for access to the engine starter.

Bearing the new designation **'aircraft 150M'** (*izdeliye* 150M, ie, *modifi**tsee**rovannyy* – modified), the fighter began State acceptance trials on 24th July 1947. These were performed by project test pilot V. Ye. Golofastov and project engineer V. I. Alekseyenko. Before the aircraft was handed over to GK NII VVS, Lavochkin test pilots made three flights to determine the stability and handling characteristics and test-fire the cannons in flight.

Still, the upgraded fighter never got a chance to pass the State acceptance trials in full; the engine went unserviceable on 9th August and no replacement engine was available, which meant the trials programme had to be halted. By then the '150M' had made only 14 flights totalling 7 hours 27 minutes. Nevertheless, some performance figures were obtained. As compared to the first prototype the modified aircraft had a take-off weight increased by 365 kg (804 lb); also, the new aerial mast, modified canopy and wingtips created additional drag. Of course, all this had a negative effect on flight performance; the top speed dropped by 73 km/h (39.45 kts) – from 878 to 805 km/h (474.59 to 435.13 kts), while the time required to reach 5,000 m increased from 4.8 to 7.2 minutes. Worse, lateral stability remained unsatisfactory in spite of the modifications and the military were still dissatisfied with the modified cockpit. All things considered, Semyon A. Lavochkin decided not to carry on with the '150M', especially since a higher-performance derivative of the same basic design, the 'aircraft 156' (described later in this chapter), had been submitted for State acceptance trials by then.

By then, however, a second 'aircraft 150' had been upgraded in a different way; this fighter was re-engined with an afterburning derivative of the RD-10 turbojet developed by the Lavochkin OKB. The use of the afterburner in air-to-air combat was to enhance the fighter's speed and agility considerably.

As already mentioned in the preceding chapters, the thrust of the RD-10 (Jumo 004B) was clearly insufficient to attain the performance figures set forth in the Soviet Air Force's general operational requirement for a jet tactical fighter. Realising this, Aleksandr S. Yakovlev and Pavel O. Sukhoi attempted to develop uprated (ie, afterburning) versions of this engine in-house at their respective OKBs, working in close co-operation with TsIAM. Semyon A. Lavochkin arrived at the same conclusion and pursued the same approach. At OKB-301 the afterburner design effort was supervised by Ivan A. Merkoolov, an aero engine designer known for his ramjet boosters of Second World War vintage who had joined the Lavochkin OKB in April 1945, bringing his design team with him.

In 1946 the special design bureau of plant No. 301 developed two consecutive versions of the afterburner. The first one retained the translating centrebody in the RD-10's nozzle with the addition of five separate combustion chambers further aft. Bench tests showed an increase in static thrust of approximately 31.9%. The afterburner was engaged more than 30 times, running for varying periods ranging from 1 to 11 minutes; the total time of afterburner operation was 1 hour 22 minutes. It turned out, however, that it was difficult to cool the centrebody and the afterburner combustion chambers which quickly burned through due to overheating.

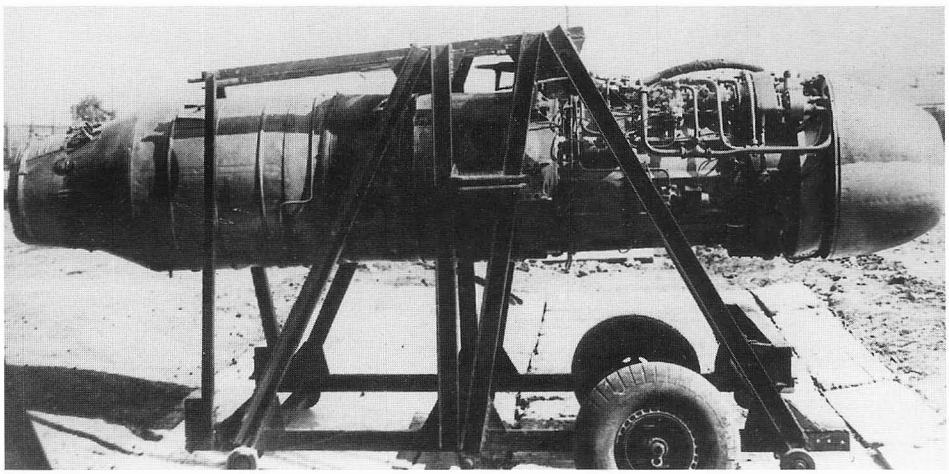
The second afterburning version of the RD-10 developed under Merkoolov's guidance therefore featured a so-called dual-action nozzle. It had a single annular combustion chamber, an annular burner in the afterburner section and movable doors adjusting the nozzle area (the translating centrebody was deleted). The nozzle doors were controlled by the standard engine controller which now worked in concert with a regulator cock controlling the fuel supply to the afterburner. An extra fuel pump was installed on the engine's accessory gearbox for feeding fuel to the afterburner. Thus the afterburner overheating problem was solved by placing all vital components outside the hot exhaust gas flow; this also simplified the design and saved weight. Unlike Yakovlev's version of the afterburning RD-10 (RD-10F), Lavochkin's version did not have an extension jetpipe.

Without the generator and the hydraulic pump (which, sure enough, were driven by the engine but considered part of the airframe's equipment) the engine had a dry weight of 761 kg (1,677 lb), a diameter of 0.83 m (2 ft 8.67 in.) and a length of 4.0355 m (13 ft 2.87 in.). The maximum thrust in afterburner mode was 1,240 kgp (2,733 lb st), which was 340 kgp (749 lb st) – ie, more than 30% – higher than the thrust of the standard RD-10; the loss of thrust at the dry rating as compared to the non-afterburning version did not exceed 30 kgp (66 lb st). Thus, retaining almost completely the dimensions and weight of the baseline RD-10 (the increase in overall length and dry weight was only 100 mm (3.93 in.) and 31 kg (68 lb) respectively), the modified engine offered considerably more power. (Some documents give a slightly lower afterburner rating for Lavochkin's version of the RD-10, stating anything from 1,050-1,100 kgp (2,314-2,425 lb st) to 1,140 kgp (2,513 lb st).) Importantly, the modification did not shorten the engine's service life.

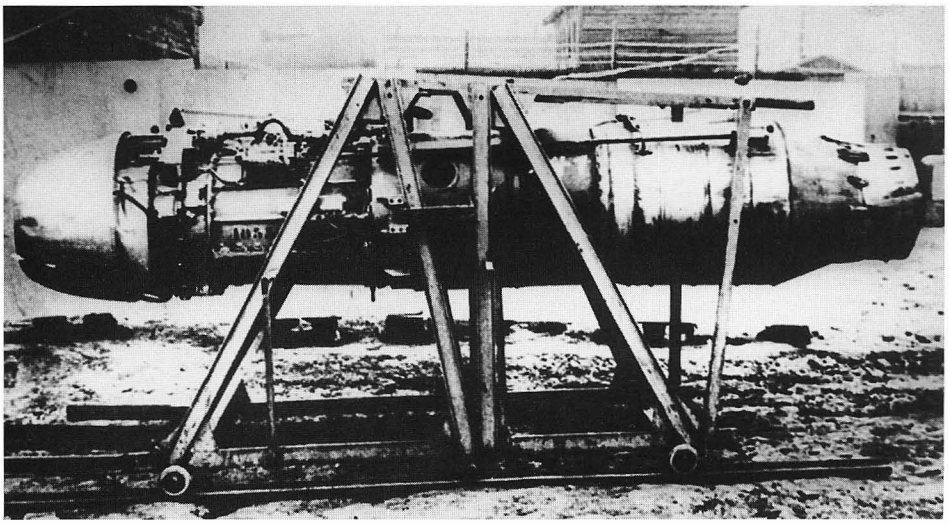
As mentioned earlier, I. A. Merkoolov (head of the Special Design Bureau at plant No. 301) had overall project responsibility. The actual work was supervised by V. I. Nizhniy, head of the plant's propulsion laboratory. The design effort was led by chief project engineer B. I. Romanenko; working with him were design group chief D. N. Chekletov, designers V. N. Kooklina and N. D. Anisimov, calculations group engineers I. S. Sorokin and A. T. Udubekov, engineer in charge of the bench tests I. A. Chornyy, engineer P. V. Karev and others.

Known in-house as *izdeliye* YuF (ie, *'**Yoo**mo', for**see**rovannyy* – Jumo [004B], uprated), the engine passed the required 25-hour bench tests in the plant's engine laboratory by 6th November 1946. (Confusingly, Lavochkin's afterburning version is sometimes called RD-10F – same as Yakovlev's version, even though they are different engines with different afterburners.) In the spring of 1947 the engine was flight-tested on the purpose-built 'aircraft 156' which was effectively an engine testbed (see below).

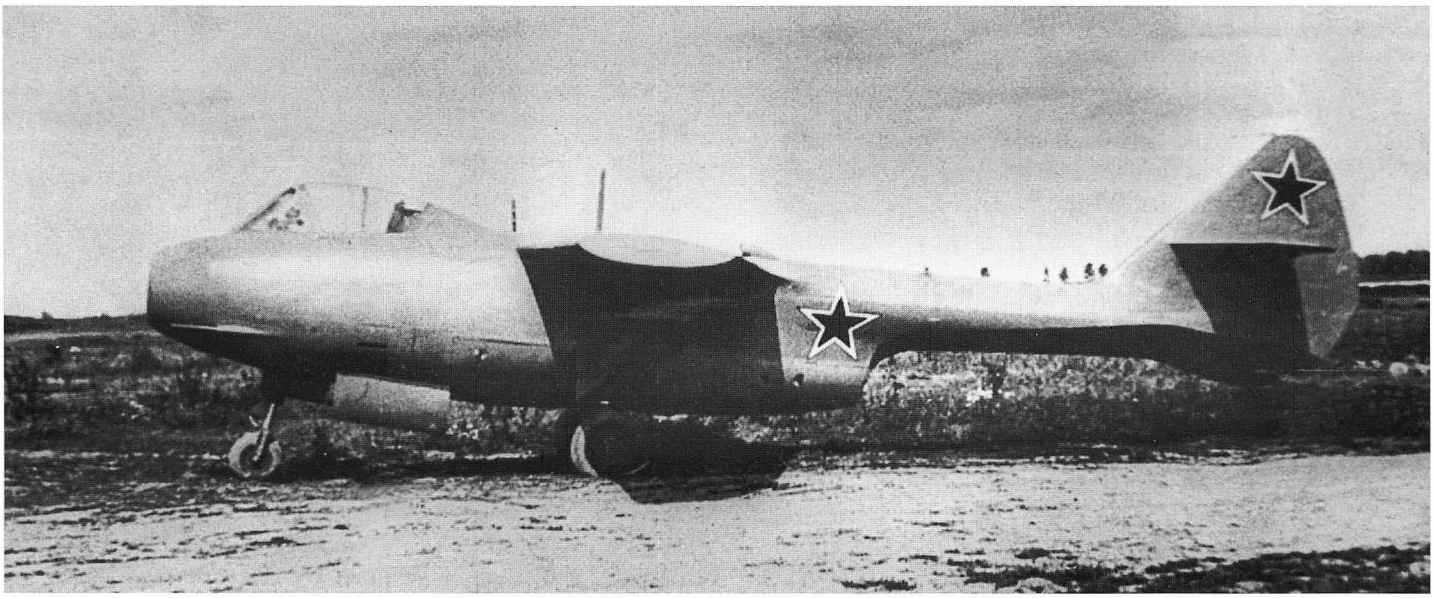
Right and below right: The izdeliye YuF afterburning turbojet on a transport trolley. The engine was evolved by the Lavochkin OKB from the RD-10 (Jumo 004B) tubojet for the 'aircraft 150F' and 'aircraft 156'. It showed better performance than the afterburning versions of the same engine developed by other Soviet aircraft design bureaux. Note the nose fairing obviously coming from a Me 262.



Below: The afterburner seen separately. The unit was developed by a design team headed by I. A. Merkoolov.



Above and below: The 'aircraft 150F' powered by the afterburning YuF engine. Note the extended engine cowling and the downward-angled wingtips.



Another view of the same aircraft during manufacturer's flight tests.

Now we come back to the previously mentioned 'aircraft 150' fighter which was converted to take the izdeliye YuF (RD-10F) engine concurrently with the development of the '150M'. Designated 'aircraft 150F', the unserialled fighter underwent manufacturer's flight tests between 25th July and 5th September 1947 at the hands of I. Ye. Fyodorov. It was immediately apparent that performance had improved appreciably; top speed increased to 950 km/h (513.51 kts) at sea level and 915 km/h (494.6 kts) at 4,320 m (14,173 ft). The fighter climbed to 5,000 m (16,404 ft) in 4.2 minutes, and range at this altitude was 487 km (302.5 miles). The '150F' was faster than the Yak-19 powered by Yakovlev's version of the RD-10F which was also undergoing tests at the time (the latter could do 904 km/h (488.64 kts) in full afterburner at 5,000 m); however, being 300 kg (661 lb) lighter, the Yak-19 had a better rate of climb, reaching 5,000 m in 3.9 minutes. Indeed, the '150F' was one of the fastest Soviet fighters at the time, ranking second only to the MiG-9 prototype powered by two RD-21 afterburning turbojets. Nevertheless, it was never submitted for State acceptance trials because the '150F' had major design shortcomings and generally its prospects looked bleak.

The main specifications of 'aircraft 150' in its various versions (as recorded during manufacturer's flight tests and State acceptance trials) are given in the table on page 110.

The deficiencies of the '150' started coming to light even as the full-scale mock-up was being built. Because of the narrow area-ruled fuselage the fighter was designed to take solely the RD-10 turbojet and could not be re-engined with the more advanced and more powerful Lyul'ka TR-1 which was too bulky to fit into the engine bay. Equally obvious were such design shortcomings as the one-piece wings built integrally with the fuselage, the cramped cockpit and the difficult access to the engine; these resulted from the need to keep structural weight down and minimise the fighter's dimensions. Likewise, the armament comprising two 23-mm cannons was considered inadequate for a fighter in those days.

Therefore, even as the work on the '150' proceeded apace, the Lavochkin OKB started working on another fighter project in late 1945. Designated **'aircraft 152'**, this fighter was again designed around the production RD-10 engine. This time the design team was facing the task of making the aircraft easier to operate and service while providing the possibility of installing other engines later on. Once again the '152' utilised the pod-and-boom fuselage design, the engine exhausting beneath the centre fuselage. This time, however, the unswept wings were mid-set rather than shoulder-mounted and the engine was installed in the forward fuselage, not aft of the cockpit.

As it were, the engine was mounted externally, the four load-bearing beams of the forward fuselage passing above it, and was enclosed from below by a large cowling (ie, the engine bay was not part of the fuselage's primary structure). Placing the engine in the extreme nose minimised the length of the inlet duct and hence thrust losses; besides, this arrangement provided easy access to the engine and allowed a more powerful engine to be installed with minimum changes to the airframe. To reduce drag the engine was installed at 6°40' to the fuselage waterline.

The cockpit was slightly widened (as compared to the '150') and moved aft to a position above the engine nozzle. It featured a bulletproof windscreen 55 mm (2.16 in.) thick, an 8-mm (0.31-in.) forward armour sheet and an 8-mm armoured seat back. Additional protection was offered by three bag-type fuel tanks ahead of the cockpit and a fourth tank aft of it; research undertaken by the Sukhoi OKB showed self-sealing fuel tanks to be quite an effective means of stopping cannon shells. From below the pilot was protected against enemy fire by the engine and the stowed mainwheels.

The wings made use of laminar airfoils which varied from root to tip; the detachable wing panels were of single-spar construction and were equipped with slotted flaps and ailerons. The ailerons and elevators were controlled by push-pull rods and bellcranks, while the rudder was actuated by cables.

Taking into account the demands of the military and learning from operational experience with the first jet fighters, the engineers bolstered the armament of the '152' with a third NS-23 cannon; two of the cannons were installed on the starboard side of the forward fuselage and one on the port side. The cannons were mounted so that the muzzles were well aft of the air intake lip; this precluded blast gas ingestion and engine flameout when the cannons were fired. The ammunition supply was reduced to 50 rpg, though.

As per ADP documents the aft-retracting main gear units were to have 600x180 mm (23.62x7.08 in.) wheels; on the actual aircraft, however, the mainwheel size was reduced to 570x140 mm (22.44x5.51 in.). The 400x150 mm (15.74x5.9 in.) nosewheel was the same as on the 'aircraft 150'; it turned through 90° during retraction to lie flat under the engine's compressor section.

The avionics and equipment suite was standard for Soviet fighters of the period. It included a radio set with an RSI-6 transmitter and RSI-6M receiver, an RPKO-10M DF, an SCh-3 IFF transponder, a gun camera, a GSK-1500 DC generator, a 12-A-10 DC battery and a KP-14 breathing apparatus with a 4-litre (0.88 Imp. gal.) oxygen bottle.

Serialled 52 Red to match the designation, the prototype 'aircraft 152' was completed in October 1946, making its first flight on 5th December; test pilots A. A. Popov and I. Ye. Fyodorov performed the manufacturer's flight test programme. Because of the bigger fuselage cross-section area and higher gross weight the '152' was slightly inferior to the '150' as regards performance, but the roomier cockpit and much simpler operational and maintenance procedures more than made up for this.

The manufacturer's flight tests were completed on 23rd June 1947, whereupon the fighter was handed over to GK NII VVS for State acceptance trials; these began on 12th July and were performed by project test pilot I. M. Dzyuba. The eighth flight, however, ended in an accident when the engine quit during final approach; the 'aircraft 152' programme was terminated and the damaged fighter was struck off charge.

In late 1946 the Lavochkin OKB made an attempt to improve the performance of the '152' by replacing the RD-10 with the 1,250-kgp (2,755-lb st) Lyul'ka TR-1 turbojet. The advanced development project of the new

The prototype 'aircraft 152' incorporated lessons learned with the '150'.

fighter bearing the manufacturer's designation **'aircraft 154'** (*izdeliye* 154) was ready in September; however, construction of the prototype which began shortly afterwards was never completed because delivery of the engine was delayed up to a point when it became clear that further development of this aircraft was pointless. Apart from the engine, the '154' differed from the '152' only in having the ammunition supply increased to 75 rpg.

The specifications of the 'aircraft 152' and the project specifications of the 'aircraft 154' are detailed in the table on page 112.

Chronologically the next aircraft developed by Lavochkin's OKB-301 was the aforementioned **'aircraft 156'** (*izdeliye* 156), a version of the 'aircraft 152' powered by the *izdeliye* YuF afterburning derivative of the RD-10 turbojet.

Design work on the '156' started on 22nd November 1946. Initially the aircraft was known as the **'aircraft 152D'** (for ***dooblyor***, second prototype) but this designation was changed to '156' on 23rd December of that year. This change of identity was justified, since there was more to it than merely an afterburner: the aircraft had major structural differences from the basic '152' as well.

The '156' featured new wings of increased span and area, utilising new airfoils optimised to delay Mach tuck. The area of the vertical and horizontal tail was likewise enlarged. The cockpit now featured an ejection seat and a redesigned canopy incorporating a 66-mm (2.6-in.) bulletproof windshield and a 72-mm (2.8-in.) rear bulletproof glass panel; the pilot was also protected by 6-mm (0.23-in.) forward armour, an 8-mm (0.31-in.) armoured seat back and a 6-mm armoured headrest.

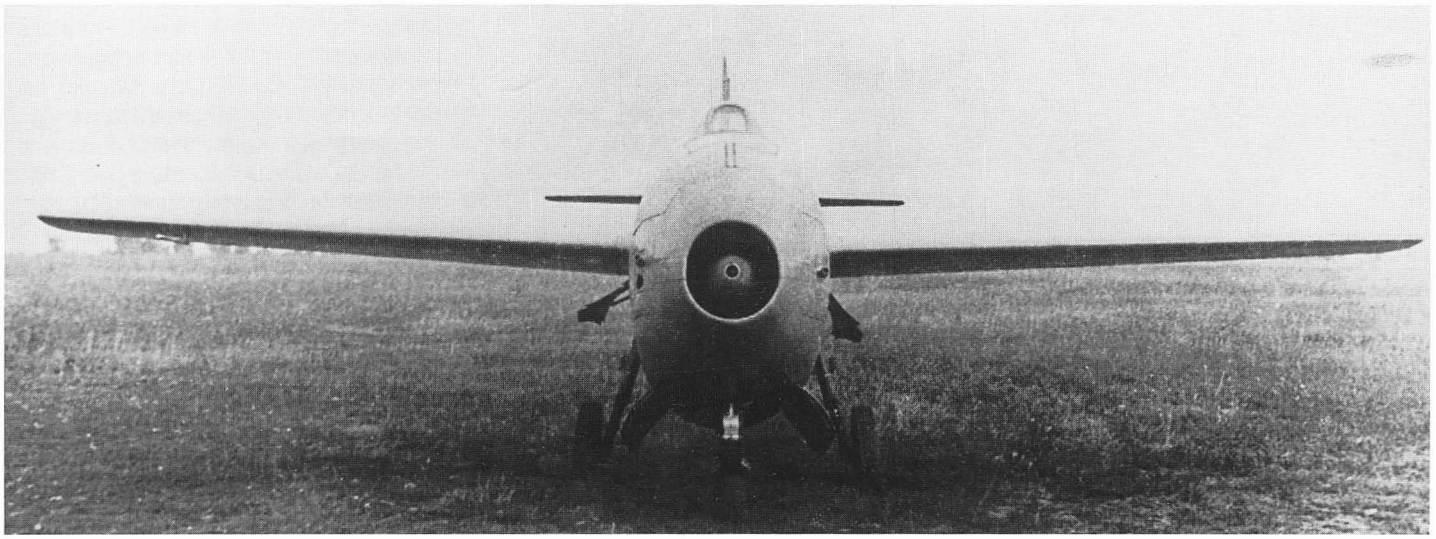
	'150' ADP project	**'150' OKB report dated 11-11-46**	**'150' manufacturer's flight tests**	**'150M' State acceptance trials**	**'150F' manufacturer's flight tests**
Powerplant	Jumo 004B	RD-10	RD-10	RD-10	*'izdeliye* YuF'
Thrust, kgp (lb st)	900 (1,984)	900 (1,984)	900 (1,984)	900 (1,984)	cca. 1100 (cca. 2,425)
Length overall	9.42 m (30 ft 10.86 in.)	9.42 m (30 ft 10.86 in.)	9.42 m (30 ft 10.86 in.)	9.418 m * (30 ft 10.74 in.)	9,425 m (30 ft 11.06 in.)
Height on ground	2.6 m (8 ft 6.36 in.)	(3.16 m) ** (10 ft 4.4 in.)	2.6 m (8 ft 6.36 in.)	2.780 m * (9 ft 1.44 in.)	(3.512 m) ** 11 ft 6.26 in.)
Wing span	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)
Stabilizer span	2.84 m (9 ft 3.8 in.)	2.84 m (9 ft 3.8 in.)	2.83 m (9 ft 3.41 in.)	2.84 m (9 ft 3.8 in.)	2.83 m (9 ft 3.41 in.)
Wing area, m^2 (sq. ft)	12.15 (130.64)	12.15 (130.64)	12.15 (130.64)	12.15 (130.64)	12.15 (130.64)
Horizontal tail area, m^2 (sq. ft)	2.08 (22.36)	2.08 (22.36)	2.08 (22.36)	2.08 (22.36)	2.08 (22.36)
Vertical tail area, m^2 (sq. ft)	n.a.	1.79 (19.24)	1.79 (19.24)	n.a.	1.79 (19.24)
Empty weight, kg (lb)	1,988 (4,382)	2,156 (4,753)	n.a.	n.a.	n.a.
Normal all-up weight, kg (lb)	2,680 (5,908)	2,910 (6,415)	2,973 (6,554)	3,338 (7,359)	3,300 (7,275)
Fuel load, kg (lb)	500 (1,102)	500 (1,102)	536 (1,181)	660 (1,455)	640 (1,411)
Wing loading, kg/m^2 (lb/sq. ft)	220.6 (45.17)	239.5 (49.17)	244.6 (50.22)	274.7 (56.4)	271.6 (55.77)
Power loading, kg/kgp (lb/lb st)	2.98	3.23	3.30	3.71	3.67
Top speed, km/h (kts):					
at sea level	840 (454)	840 (454)	n.a.	n.a.	950 (513.51)
at altitude, m (ft)	850 (459.45)/ 5,000 (16,404)	850 (459.45)/ 5,000 (16,404)	878 (474.59)/ 4,200 (13,779); 850 (459.45)/ 8,240 (27,034)	805 (435.13)/ 5,000 (16,404)	915 (494.6)/ 4,320 (14,173); 900 (486.48)/ 6,270 (20,570)
Landing speed, km/h (kts)	150 (81)	150 (81)	n.a.	n.a.	n.a.
Climb time to 5,000 m (16,404 ft), min	4.0	5.2	4.8	7.2	4.2
Rate of climb. m/sec (ft/min):					
at sea level	n.a.	19.0 (3,739)	22.1 (4,349)	15.0 (2,952)	26.0 (5,116)
at altitude, m (ft)	n.a.	n.a.	n.a.	n.a.	14.8 (2,912)
Altitude gain in a combat turn from 1,000 m (3,280 ft), m (ft)	n.a.	n.a.	2,000-2,200 (6,561-7,217)	1,800 (5,905)	n.a.
Service ceiling, m (ft)	14,000 (45,931)	12,500 (41,010)	12,600 (41,338)	n.a.	n.a.
Maximum range at 5,000 m (16,404 ft), km (miles)	n.a.	670 (416) ***	493 (306)	n.a.	487 (302)
Endurance at 5,000 m (16,404 ft)	n.a.	6 hrs 06 min***	48 min	n.a.	50 min
Take-off run, m (ft)	n.a.	1,000 (3,280)	760 (2,493)	1,140 (3,740)	n.a.
Landing run, m (ft)	n.a.	610 (2,001)	780 (2,559)	1,000 (3,280)	n.a.
Armament	2 x NS-23 w. 75 rpg	2 x NS-23 w. 75 rpg	2 x NS-23 w. 75 rpg	2 x NS-23 w. 70 rpg	2 x NS-23 w. 70 rpg

Notes:

** According to general arrangement drawing.*

*** These are the figures stated in OKB documents. This is probably the aircraft's height with the landing gear in no-load condition.*

**** At 8,000 m (26,246 ft) and 600 km/h (324 kts); at 840 km/h (454 kts) the design range is 300 km (186 miles), with an endurance of 21.4 minutes.*



The photos on this page depict the first prototype 'aircraft 156' (56 Red) during manufacturer's flight tests.

	'152' OKB report dated 11-11-46	'152' Manufacturer's flight tests	'154' ADP project	'154' OKB report dated 11-11-46
Powerplant	RD-10	RD-10	TR-1	TR-1
Thrust, kgp (lb st)	1,250 (2,755)	900 (1,984)	1,250 (2,755)	1,250 (2,755)
Length overall	9.04 m (29 ft 7.9 in.) [1]	9.04 m (29 ft 7.9 in.) [1]	9.42 m (30 ft 10.86 in.)	9.42 m (30 ft 10.86 in.)
Height on ground	2.65 m (8 ft 8.33 in.)	n.a.	2.95 m (9 ft 8.14 in.)	2.95 m (9 ft 8.14 in.)
Wing span	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)	8.2 m (26 ft 10.83 in.)
Stabilizer span	2.8 m (9 ft 2.23 in.) [1]	2.8 m (9 ft 2.23 in.) [1]	2.8 m (9 ft 2.23 in.)	2.8 m (9 ft 2.23 in.)
Wing area, m² (sq. ft)	12.15 (130.64)	12.15 (130.64)	12.15 (130.64)	12.15 (130.64)
Horizontal tail area, m² (sq. ft)	2.1 (22.58)	2.1 (22.58)	2.1 (22.58)	2.1 (22.58)
Vertical tail area, m² (sq. ft)	2.0 (21.5)	2.0 (21.5)	2.0 (21.5)	2.0 (21.5)
Empty weight, kg (lb)	2,227 (4,909)	2,310 (5,092)	2,382 (5,251)	2,410 (5,313)
Payload, kg (lb)	793 (1,748)	850 (1,873)	1,108 (2,442)	1,081 (2,383)
Normal all-up weight, kg (lb)	3,020 (6,657)	3,160 (6,966)	3,490 (7,694)	3,490 (7,694)
Fuel load, kg (lb)	600 (1,322)	620 (1,366)	870 (1,918)	867 (1,911)
Wing loading, kg/m² (lb/sq. ft)	248.6 (51.04)	260.0 (53.38)	280.0 (57.49)	287.0 (58.93)
Power loading, kg/kgp (lb/lb st)	3.35	3.55	3.23	3.23
Top speed, km/h (kts):				
at sea level	840 (454.0)	n.a.	925 (500.0)	925 (500.0)
at 3,000 m (9,842 ft)	n.a.	830 (448.64)	n.a.	n.a.
at 5,000 m (16,404 ft)	860 (464.86)	840 (454.0)	919 (496.75)	920 (497.29)
Landing speed, km/h (kts)	165	n.a.	154	n.a.
Climb time, min:				
to 5,000 m (16,404 ft)	5.6	5.6	3.7	3.7
to service ceiling	n.a.	n.a.	28.4	n.a.
Rate of climb. m/sec (ft/min):				
at sea level	18.0 (3,542)	n.a.	26.5 (5,215)	n.a.
at 6,000 m (19,685 ft)	n.a.	n.a.	17.4 (3,424)	n.a.
at 10,000 m (32,808 ft)	n.a.	n.a.	7.5 (1,476)	n.a.
Service ceiling, m (ft)	12,500 (41,010)	12500 (41,010)	12,850 (42,158)	13,000 (42,651)
Maximum range km (miles):				
at sea level	340 (211) [2]	n.a.	570 (354) [6]	400 (248) [7]
at 5,000 m (16,404 ft),	n.a.	495 (307)	n.a.	n.a.
at 8,500 m (27,887 ft)	700 (434) [3]	n.a.	n.a.	n.a.
at 10,000 m (32,808 ft)	n.a.	n.a.	1,090 (677) [8]	1,100 (683) [9]
Endurance:				
at sea level	24.5 min [2]	n.a.	26 min [10]	26 min [10]
at 5,000 m (16,404 ft),	n.a.	55 min	n.a.	n.a.
at 8,500 m (27,887 ft)	1 hr 18 min [4]	n.a.	n.a.	n.a.
at 10,000 m (32,808 ft)	n.a.	n.a.	1 hr 48 min [11]	1 hr 51 min [5]
Take-off run, m (ft)	1,200 (3,937)	796 (2,611)	1,130 (3,707)	1,150 (3,773)
Landing run, m (ft)	860 (2,821)	740 (2,427) [5]	662 (2,172)	660 (2,172)
Armament	3 x NS-23 w. 50 rpg	3 x NS-23 w. 50 rpg	3 x NS-23 w. 75 rpg	3 x NS-23 w. 75 rpg

Notes:

1. Some documents state the overall length as 9.12 m (29 ft 11 in.) and the stabilizer span as 2.84 m (9 ft 3.8 in.).
2. At 840 km/h (454.0 kts)
3. At 600 km/h (324.32 kts)
4. At 480 km/h (259.45 kts)
5. At 540 km/h (291.89 kts)
6. At 415 km/h (224.32 kts)
7. At 925 km/h (500.0 kts)
8. At 700 km/h (378.37 kts)
9. At 680 km/h (367.56 kts); endurance in maximum range cruise 1 hour 36 minutes
10. At maximum speed (925 km/h; 500 kts)
11. At 530 km/h (286.48 kts)

The landing gear was unchanged as compared to the '152', featuring the same wheel size, narrow track (1.76 m/5 ft 9.29 in.) and short wheelbase (1.972 m/6 ft 5.63 in.); on the ground the aircraft sat at a 2°02' nose-up angle. The avionics and equipment were likewise identical to those of the '152'.

Two examples of the 'aircraft 156' were built. Aptly serialled 56 Red, the first prototype was completed and trucked to LII in February 1947, making its first flight on 1st March with factory test pilot S. F. Mashkovskiy at the controls. M. Baranovskiy and I. A. Chornyy were assigned engineers in charge of the manufacturer's flight tests with responsibility for the airframe/systems and the powerplant respectively. Dry power was used in the early test flights; only after 20th March did ground runs of the engine in afterburner mode begin.

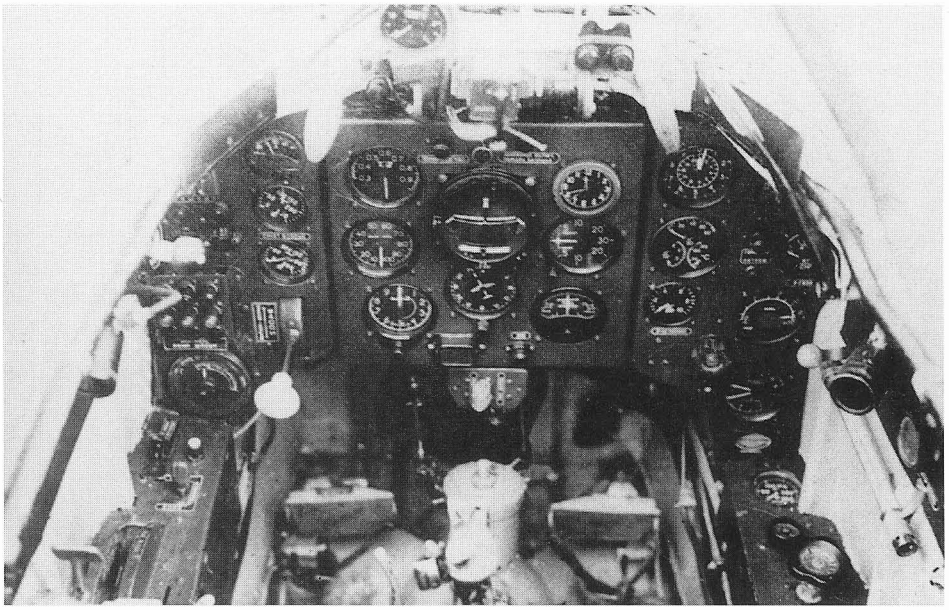
The unserialled second prototype arrived at LII's airfield on 19th March, joining the test programme on 28th March at the hands of N. P. Krivosheyin, another factory test pilot. Once again the afterburner was not used in the first flight. All three Lavochkin OKB test pilots – Mashkovskiy, Krivosheyin and Fyodorov – got a chance to fly both prototypes of the '156' at this stage of the tests.

In early April the first prototype made a high-speed taxi run with the afterburner engaged. On 10th April S. F. Mashkovskiy performed the first afterburner take-off of a jet aircraft in Soviet aircraft development history; the 'burner was engaged when the fighter had climbed to 300-400 m (984-1,312 ft). Two days later Mashkovskiy checked the afterburner's operation at altitudes ranging from 500 to 5,000 m (1,640 to 16,404 ft).

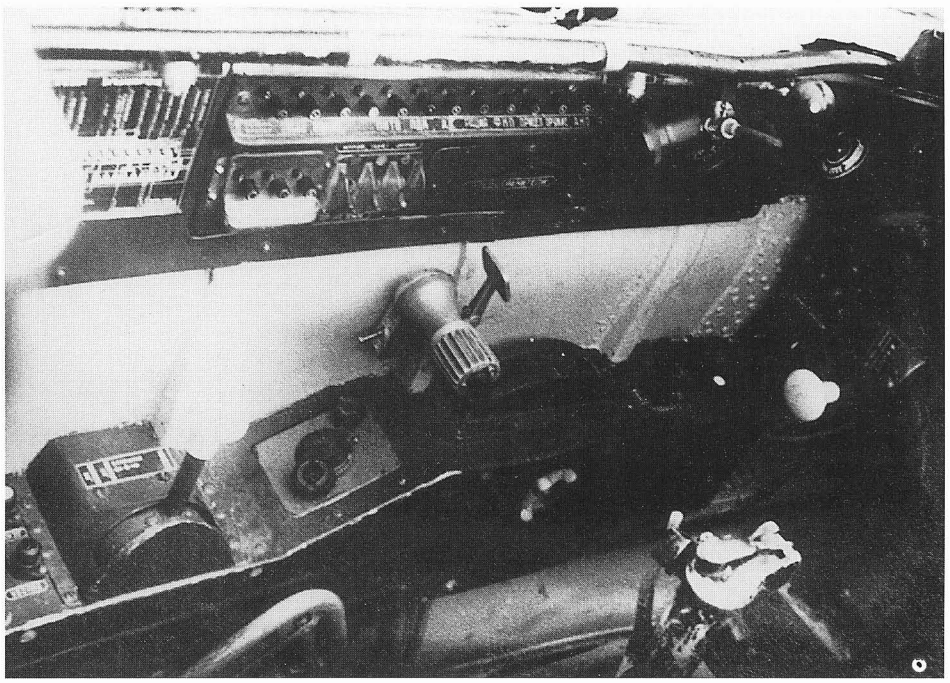
Changes were made to the engine control system in the course of the tests, simplifying its operation considerably. The afterburner ignited reliably and functioned normally all the way. The manufacturer's tests of the 'aircraft 156' and the *izdeliye* YuF engine lasted until 20th August 1947, the two prototypes making a total of 62 flights. It was established that the engine could run in full afterburner for up to ten minutes at a time; by comparison, the maximum continuous afterburner operation time during bench tests was 12 minutes. At altitudes between 3,000 and 7,000 m (9,842 to 22,965 ft) the '156' was 40 to 75 km/h (21.6 to 40.5 kts) faster than the '152'. Piloted by S. F. Mashkovskiy, the '156' took part in the Tushino flypast on 3rd August 1947 along with other jet fighter prototypes.

On 27th August the second prototype was submitted for State acceptance trials which duly began on 9th September and were performed by GK NII VVS test pilot A. G. Terent'yev. More alterations were made to the engine control system at this stage; these not only ensured reliable afterburner ignition after a long dive (during which the engine's turbine

Above: The '156' at GK NII VVS during State acceptance trials.



Above: The instrument panel of the 'aircraft 156'.



The port cockpit wall and control console of the '156'.

The '174TK' was Lavochkin's last fighter to employ the pod-and-boom arrangement and unswept wings.

	Manufacturer's flight tests	State acceptance trials
Powerplant	*izdeliye* YuF	*izdeliye* YuF
Thrust, kgp (lb st)	cca. 1,100 (2,425)	1,050 (2,314)
Length overall	9.12 m (29 ft 11 in.)	9.12 m (29 ft 11 in.)
Height on ground	n.a.	n.a.
Wing span	8.52 m (27 ft 11.43 in.)	8.52 m (27 ft 11.43 in.)
Stabilizer span	3.0 m (9 ft 10.11 in.)	3.0 m (9 ft 10.11 in.)
Wing area, m^2 (sq. ft)	13.24 (142.36)	13.24 (142.36)
Horizontal tail area, m^2 (sq. ft)	2.301 (24.74)	2.301 (24.74)
Vertical tail area, m^2 (sq. ft)	2.197 (23.62)	2.197 (23.62)
Empty weight, kg (lb)	2,544 (5,608)	2,398 (5,286)
Payload, kg (lb)	936 (2,063)	1,123 (2,475)
Normal all-up weight, kg (lb)	3,480 (7,672)	3,521 (7,762)
Fuel load, kg (lb)	743 (1,638)	756 (1,666)
Wing loading, kg/m^2 (lb/sq. ft)	261 (53.59)	264 (54.2)
Power loading, kg/kgp (lb/lb st)	3.05	3.35
Top speed in full 'burner/at full mil power, km/h (kts):		
at sea level	n.a.	845/n.a. (456.75/n.a.)
at 2,000 m (6,561 ft)	n.a.	905/680 (489.19/367.56)
at 3,000 m (9,842 ft)	900/n.a. (486.48/n.a.)	n.a.
at 5,000 m (16,404 ft)	882/n.a. (476.75/n.a.)	868/701 (469.19/378.91)
Landing speed, km/h (kts)	n.a.	185 (100)
Climb time to 5,000 m (16,404 ft) in full afterburner/at full military power, min	4.2./n.a.	4.0/7.6
Rate of climb in full afterburner. m/sec (ft/min):		
at sea level	23.0 (4,526)	23.6 (4,644)
at 5,000 m (16,404 ft)	18.3 (3,601)	18.7 (3,680)
at 8,000 m (26,246 ft)	n.a.	15.0 (2,952)
at 10,000 m (32,808 ft)	13.5 (2,656)	n.a.
Service ceiling, m (ft)	10,000 (32,808)	10,700 (35,104)
Maximum range km (miles):		
at 5,000 m (16,404 ft)	620 (385)*	505 (313)
at 8,000 m (26,246 ft)	n.a.	540 (335)
at 10,000 m (32,808 ft)	n.a.	620-660 (385-409)*
Endurance:		
at 5,000 m (16,404 ft)	1 hr 5 min	57 min
at 8,000 m (26,246 ft)	n.a.	1 hr 2 min
Take-off run, m (ft)	620 (2,034)	1,000 (3,280)
Landing run, m (ft)	780 (2,559)	950 (3,116)
Armament	3 x NS-23	3 x NS-23
Ammunition supply (total)	190	190

** Estimated range; true figures could not be obtained due to unreliable engine operation above 8,000 m.*

temperature would drop to 440-500°C) but also permitted the aircraft's performance and handling characteristics in afterburner mode to be explored to the full. Performance had improved markedly as compared to the 'aircraft 152' and the 'burner functioned reliably at various speeds and altitudes; however, afterburner operation was not checked above 8,000... 9,000 m (26,246... 29,527 ft).

The testing of the '156' marked another 'first' for the Soviet fighter design school. The State acceptance trials programme included three sessions of mock combat with a MiG-9 during which the '156' made use of the afterburner in a 'dogfight' for the first time. When the afterburner was not used, neither fighter could gain an advantage as the '156' and the MiG-9 chased each other. On the third occasion, however, the Lavochkin fighter quickly fastened itself onto the MiG's tail after igniting the afterburner, regardless of whether the engagement took place in the horizontal or in the vertical plane; the 'dogfight' took place at 6,000-8,000 m (19,685-26,246 ft).

Still, the '156' was beset by the same troubles that had plagued its non-afterburning stablemates; the engine also had its share of bugs. However, the advisability of refining *izdeliye* YuF to the point where it was ready for production was questionable, since a wholly indigenous turbojet offering much greater thrust was already being tested at the time.

The State acceptance trials were completed on 28th (some documents say 31st) January 1948, involving 54 flights. The concluding part of the trials report prepared by GK NII VVS said, among other things:

'... b) The system for combusting additional fuel in the jetpipe of the RD-10 engine [...] does indeed improve the aircraft's performance but needs refining and has a number of serious shortcomings, which means it cannot be recommended for introduction in its present condition...

c) The aircraft has serious shortcomings as regards longitudinal stability, high stick forces from the ailerons and elevators, a troublesome undercarriage retraction system...'

The verdict was clear: *'The '156' fighter cannot be recommended for Air Force service.'* Since the aircraft held no promise, all further work on the '156' was abandoned.

The table on this page illustrates the performance of 'aircraft 156'. Note that the afterburner rating of the *izdeliye* YuF engine is stated differently in different documents; however, both figures may be correct, since this was an experimental engine and the thrust of prototype engines may vary appreciably.

In subsequent years OKB-301 developed more advanced jet fighters; one of them, the '174D', even saw limited production and service with the Soviet Air Force as the La-15.

Chapter 5

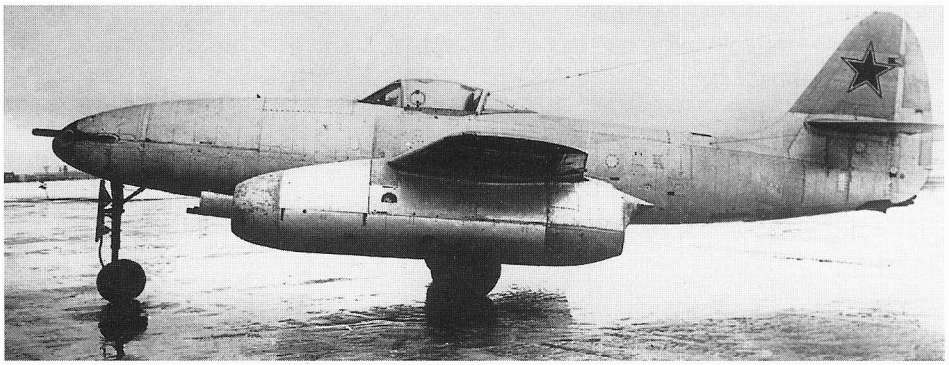
Sukhoi's Early Twinjets

The design bureau headed by Pavel Osipovich Sukhoi had started working on jet fighters back in the mid-1940s. At that time Sukhoi's design team developed a spate of fighter projects. Some of them had different kinds of mixed powerplants (for instance, the Su-5 featuring a piston engine driving a tractor propeller augmented by a 'pseudo-turbojet' booster with a shaft-driven compressor, or the more conventional project of 1943 combining a piston engine driving a tractor prop with two ramjets in underwing pods). Others were pure jet aircraft, such as the rather unusual project of 1942 with a turbojet engine in the rear fuselage breathing through an annular intake aft of the teardrop-shaped cockpit section. However, with the exception of the Su-5, none of these projects was to progress further than preliminary studies.

In 1944 P. O. Sukhoi, whose OKB was then at the premises of aircraft factory No. 134, began development of a fighter powered by two turbojets designed by Arkhip M. Lyul'ka and mounted in underwing nacelles. In December of that year the project was included into the draft of the Soviet aircraft industry's development plan for the coming year, with a rollout date provisionally set for December 1945. In the first quarter of 1945 the project was approved by the 7th Main Directorate of NKAP which postponed the tentative rollout date to 1st March 1946. In the course of 1945 Sukhoi's jet fighter project was eliminated from the development plan and reinstated several times. Unperturbed by these changes of mind at the top level, Sukhoi continued steadily working on the fighter which was known in-house as ***izdeliye* K**; the official designation **Su-9** was allocated later.

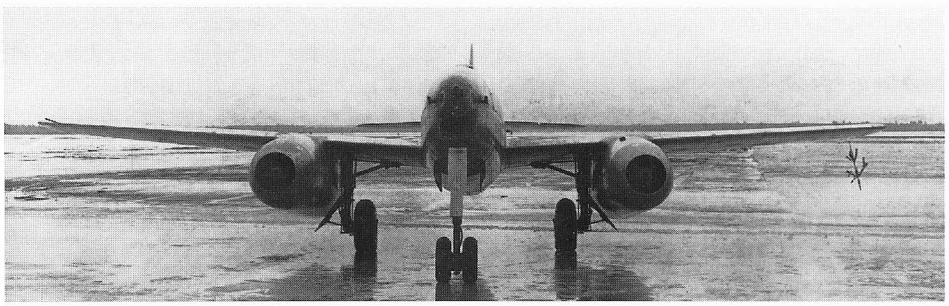
(As would later be the case with the straight-wing Yak-25, this was the first fighter to be thus designated. The designation Su-9 was reused in 1957 for a single-engined supersonic interceptor bearing the in-house designation T-43 (NATO code name *Fishpot-A*) which saw production and service with the Soviet Air Force. However, this happened after the liquidation and subsequent rebirth of the Sukhoi OKB and thus lies outside the scope of this book.)

Outwardly the Su-9 bore a considerable resemblance to the Messerschmitt Me 262. The authors of many prior features on the



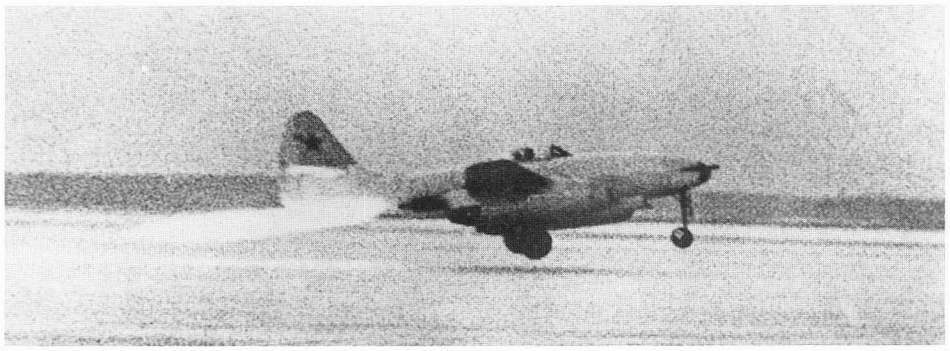
Above: A side view of the first fighter to bear the designation Su-9 (the *izdeliye* K of 1945).

Above: The Su-9 bore a striking resemblance to the Me 262 and was powered by the same engines.

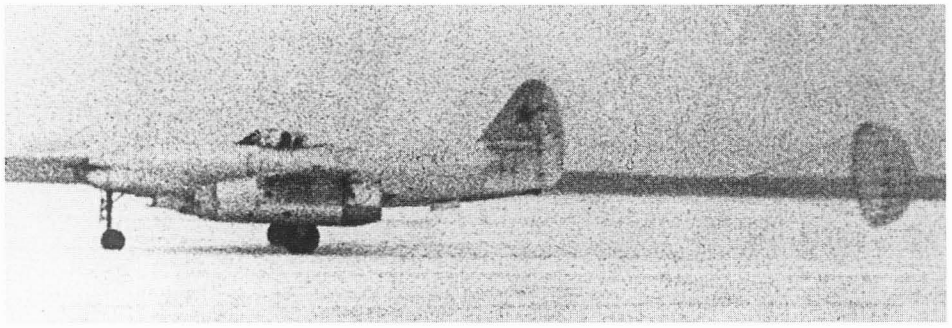


Front view of the Su-9.

Su-9 are adamant that it was not 'a copy of the German fighter'. It is true, of course, that the Su-9 was by no means a direct copy of the Me 262 (eg, the fuselage was of elliptical cross-section instead of quasi-triangular); yet the choice of *izdeliye* K's general arrangement was very probably (in fact, almost certainly) influenced by the evaluation of a captured Me 262 by the specialists of GK NII VVS, TsAGI and LII – among other things, from the technology standpoint. (Speaking of which, the projected I-260 twinjet fighter was under development at Artyom I. Mikoyan's OKB-155 at the same time, as recounted in Chapter One, and this fighter's external similarity to the Me 262 was too much to be a mere coincidence!) Pavel O. Sukhoi believed the chosen underwing engine placement to offer



Above: The Su-9 takes off, making use of U-5 JATO rockets.



The Su-9 streams its brake parachute on landing.

greater advantages than the layout with the engines buried in the fuselage.

Sukhoi engineers went to great lengths to make the Su-9's airframe as aerodynamically clean as possible. No less attention was paid to structural design. The fighter had a very high wing loading – more than 300 kg/m² (1,458 lb/sq. ft), which allowed the overall dimensions to be reduced and the top speed to be increased. On the down side, take-off and landing speeds were also high, which meant a long runway would be required. To shorten the take-off run the Su-9 was to make use of U-5 jet-assisted take-off (JATO) bottles delivering 1,150 kgp (2,535 lb st) each; U stood for *ooskor**it**el'* (booster). The boosters were mounted on the fuselage sides behind the wing trailing edge and jettisoned by means of special locks after burnout. With an eight-second burn time, the JATO bottles reduced the take-off run by nearly 50% to 457 m (1,499 ft). The Su-9 was also one of the first Soviet fighters to feature a brake parachute; this shortened the landing run by 30% to 660 m (2,165 ft).

The Su-9 fighter was one of the first Soviet combat aircraft to feature an ejection seat and a canopy jettison system. There have been claims that the Ye-24 cartridge-fired ejection seat had been designed by the OKB of plant No. 134 from beginning to end; in reality, however, it was a direct copy of the seat fitted to the Heinkel He 162 jet fighter, an example of which had also been captured and thoroughly evaluated in the USSR. The Su-9 also has the distinction of being the first Soviet aircraft to have powered controls, featuring irreversible hydraulic actuators in the control system.

As already mentioned, the aircraft was originally designed with Lyul'ka engines in mind – specifically, S-18 axial-flow turbojets rated at 1,300 kgp (2,866 lb st). Unfortunately, development of this engine (redesignated TR-1 in its flight-cleared version) was facing severe delays; therefore, Pavel O. Sukhoi suggested using Junkers Jumo 004B axial-flow turbojets instead, since the Ufa engine factory No. 26 was about to launch production of this engine as the RD-10. Early in the fourth quarter of 1945 the Sukhoi OKB sent a revised advanced development project of *izdeliye* K powered by two Jumo 004 engines to the 7th Main Directorate of NKAP; the Commissariat's expert panel approved it on 15th October. After that, the project was submitted to GK NII VVS which likewise returned a positive verdict on 15th December.

On 7th February 1946 a full-scale mock-up of the Su-9 was inspected by the mock-up review commission and duly approved; the Soviet Air Force C-in-C signed the Act of Acceptance on 16th February. In accordance with Council of People's Commissars directive No. 472-191ss of 26th February and the appropriate order of the People's Commissar of Aircraft Industry issued on 27th March the construction of the *izdeliye* K fighter prototype was included into the production plan of aircraft factory No. 134, with the manufacturer's flight tests scheduled to begin on 1st November 1946. After making the necessary changes recommended by the mock-up review commission the OKB issued the prototype's manufacturing drawings to the production department on 25th April; meanwhile, construction of the static test airframe had begun back in March.

Despite government orders, the development schedule of *izdeliye* K kept slipping; plant No. 134 was unable to keep up with the tight schedules set forth in the government directives because it was also responsible for developing the UTB trainer derivative of the Tupolev Tu-2 *Bat* bomber (UTB = *oo**cheb**no-treni**rov**ochnyy bombardi**rov**schchik* – bomber trainer). The reason why the job had been assigned to Sukhoi is that Andrey N. Tupolev had turned down the job; of all the Soviet aircraft designers, he alone was in a position to do so because his OKB-156 had several important all-new bomber projects in the making. Aleksandr S. Yakovlev, who was Vice People's Commissar of Aircraft Industry at the time, had tasked the Sukhoi OKB with the UTB programme back in late January 1946 – again setting an extremely tight development and prototype construction schedule of only six months. This added responsibility taxed the resources of Sukhoi's design team heavily, inevitably causing the jet fighter's development to slow down. This, incidentally, improved the chances of competing design bureaux – including the Yakovlev OKB; as we know, A. S. Yakovlev was also working on first-generation jet fighters and was eager to see them put into mass production (makes you wonder if his decision to assign the UTB programme to Sukhoi was a deliberate step aimed at setting the competitor back!). Another contributory cause was the fact that TsAGI often took longer than expected to give recommendations on the use of the laminar airfoils developed by this institute. Worse, sometimes TsAGI withdrew its own recommendations issued previously and gave new ones; Sukhoi OKB engineers had to rework the Su-9's wings three times because of this!

Prototype construction was also delayed by late delivery of numerous instruments and equipment items which had been 'subcontracted' out to other NKAP factories. The requirement to use JATO bottles to reduce the take-off run led to more complications. It turned out that the rocket boosters developed by NII-1 did not deliver enough thrust and had an insufficient burn time; besides, the Soviet aircraft industry had no prior experience of using JATO bottles on aircraft. To top it all, the Sukhoi OKB was forced to make manufacturing drawings for fitting the boosters to a Bell P-39 Airacobra and a North American B-25 Mitchell which served as propulsion testbeds. In his report to MAP on the state of the izdeliye K fighter programme, Deputy Chief Designer of plant No. 134 Goorko wrote on 26th July 1946 that *'despite insistent demands of the Minister to attach top priority to jet aircraft*

development, and despite the reports on progress and component deliveries from other factories which the plant sends thrice weekly to Vice-Minister Comrade Shishkin, the situation remains dire'. A similar note was sent to the Chief Controller of the Soviet Ministry of State Control.

Still, despite these problems caused by reasons beyond the OKB's control, static tests of *izdeliye* K commenced in July 1946. At the same time the flying prototype was being outfitted with engines – rather later than expected because of the late delivery of production RD-10 turbojets. The static tests were completed by mid-October, as was final assembly of the prototype. The bottom line is that the fighter was rolled out three months late, taking seven months to build (from March to November 1946).

Pilots are a superstitious lot, but the desire (or, more likely, the pressure) to get the plane into the air was too great. On 13th November 1946, when initial taxiing trials had been completed and some design faults in the landing gear eliminated, test pilot Gheorgiy M. Shiyanov successfully performed the Su-9's maiden flight. Sergey N. Anokhin and A. G. Kochetkov also flew the aircraft; the latter pilot's opinion was of special importance to Pavel O. Sukhoi, since Kochetkov had also flown the captured Me 262A-1a at GK NII VVS and was in a position to compare the two fighters.

In his report Shiyanov wrote that *'the aircraft is easy and pleasing to fly'*. When the controls had been adjusted by means of trim tabs, the fighter could fly on one engine without departing from controlled flight, even when the controls were released. Dead-stick landings (ie, landings with the engines shut down) presented no problems either. The Su-9 could easily be called a maintenance man's dream, since all major equipment items were readily accessible and the tech staff could work on all of the aircraft's systems at once.

While stating that the Su-9 had a good chance of entering production, the pilots noted nevertheless that control forces were excessively high at high speeds. Providing this problem was cured, however, the Su-9 could be easily mastered by the average fighter pilot – or even a pilot with below-average skills. With an all-up weight of 5,782 kg (12,747 lb), the aircraft attained a top speed of 885 km/h (478.37 kts) during manufacturer's flight tests and climbed to 5,000 m (16,404 ft) in 4.7 minutes.

The Sukhoi OKB was quick to react to the test pilots' comments and suggestions, making changes to the Su-9's control system. As already mentioned, hydraulic boosters for the fighter's ailerons and elevators was developed and manufactured in house. Besides, the early test flights revealed poor directional stability; the vertical tail area needed to be enlarged, and this was done in due course.

Like many other Soviet aircraft design bureaux, in the spring of 1947 the OKB of plant No. 134 was instructed to prepare prototypes of new jet aircraft for the traditional Tushino flypast in August which was the showcase of the Soviet aircraft industry. The order to this effect issued by the Minister of Aircraft Industry read: *'...Chief Designer and Director of plant No. 134 Sukhoi shall have the 'K' twin-engined fighter with RD-10 engines ready by 20th July; he shall also complete assembly of the 'LK' twin-engined fighter with TR-1 engines by 25th May and complete flight tests of same by 1st August.'*

The demands were met. Flown by GK NII VVS test pilot A. G. Kochetkov, the Su-9 took part in the Tushino show on 3rd August 1947. Three days later the fighter was formally turned over to GK NII VVS for State acceptance trials, arriving at the institute's flight test facility at Chkalovskaya AB on 18th August. Then the aircraft was returned to the manufacturer for fitment of the hydraulic control actuators, whereupon flight tests resumed at LII. The powered controls test programme proceeded from 27th March to 25th May 1948 and involved eleven flights totalling 5 hours 13 minutes. In these flights, stick forces were measured at various speeds with the hydraulic actuators turned on and off, and the relationship between stick forces and aileron/elevator deflection was determined.

All in all, the Su-9 made 136 flights between 13th November 1946 and 25th May 1948, logging 58 hours 58 minutes total time. In the course of the trials the fighter attained a top speed of 847 km/h (457.83 kts) at sea level and 885 km/h (478.37 kts) at 8,000 m (26,246 ft). The service ceiling was 12,800 m (41,994 ft) and endurance was 1 hour 44 minutes. The aircraft was recommended for production, but too late – other fighter types had entered production in the meantime, and the Soviet government would not finance further development of the Su-9 at OKB-134. Though the sole prototype was still airworthy and could have been used for other development work, it was struck off charge and ultimately scrapped.

Back in 1946 the Sukhoi OKB proposed a dual-control trainer version of the Su-9 designated **Su-9UT** (*oo**cheb**no-treni**rov**ochnyy* – training, used attributively). Powered by RD-10 engines, the trainer differed from the basic fighter mainly in having two separate cockpits enclosed by individual canopies for the trainee and instructor – an unusual arrangement which was later used on several other Soviet jet trainers. To give the trainee the best possible field of view for take-off and landing, the trainee's cockpit was placed ahead of the instructor's. The armament consisted of two 20-mm (.78 calibre) B-20 cannons with 100 rpg. No armour protection was provided to save weight. The Su-9UT was never built because the government had cancelled the Su-9 programme.

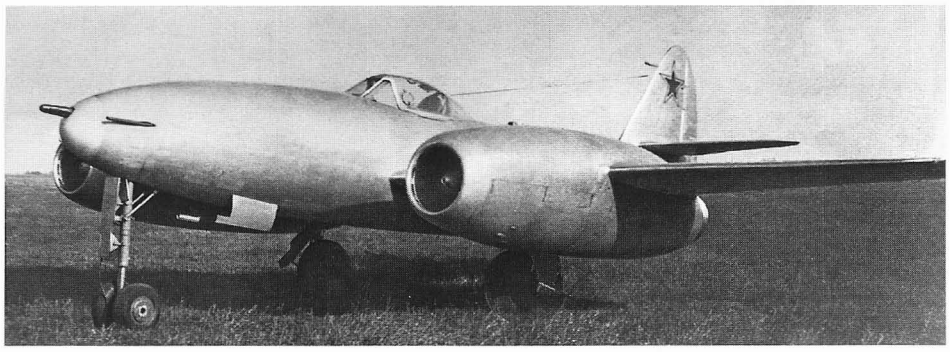
A few lines earlier it has been said that only a sole prototype existed; actually there should have been two, but the second aircraft eventually emerged as a new type. Design work on the second prototype Su-9 started almost simultaneously with the Su-9UT trainer, and the aircraft incorporated a number of important changes. The powerplant envisaged at this stage consisted of two RD-10F afterburning turbojets. As recounted in Chapter Three, the afterburning version had been jointly developed by Yakovlev's OKB-115 and the Central Institute of Aero Engines (TsIAM) to meet a specification for the Yak-19's powerplant. However, on the latter fighter the engine was buried in the fuselage; installing RD-10Fs in the Su-9's underwing nacelles required the rear portions of both nacelles and engines to be modified.

Sukhoi OKB engineers undertook a major design effort together with TsIAM to adapt the RD-10F for underwing installation. The new afterburner had double walls of heat-resistant steel sheet; cooling air was forced between the inner and outer walls. A supplementary engine-driven pump fed fuel to six fuel atomizers installed in the afterburner. The tailcone located aft of the turbine on the basic RD-10 was replaced by two flaps for adjusting the nozzle area; these, like the abovementioned tailcone, were controlled by an automatic nozzle governor. Tests held jointly by Sukhoi and TsIAM showed that the arrangement worked satisfactorily and the engine was recommended for the second prototype Su-9.

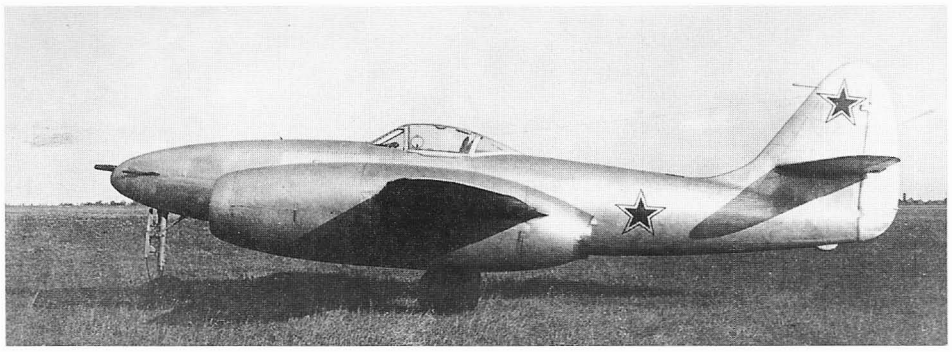
In mid-September 1946, however, TsAGI completed tests of a scale model of the Su-9 in the T-106 wind tunnel; these confirmed earlier suggestions that the fighter's performance could be improved by aligning the engine axes with the wing chord. Placing the engine nacelles in this fashion significantly reduced the harmful interference between wings and nacelles as compared to the underwing location, reducing overall drag at high Mach numbers.

At the same time the wings proper were also redesigned to use a new TsAGI SR-3-12 airfoil at the tips instead of the earlier TsAGI KV-3-12 (the TsAGI S-1-12 airfoil used on the inner wings was retained). Further wind tunnel tests showed that the redesign significantly reduced Mach tuck at critical Mach numbers and precluded rudder force reversal.

To implement these changes the wing structure had to be redesigned. Since the nacelle axes were now almost level with the wing chord plane, the main spar and the front



Above: The Su-11 (*izdeliye* LK) fighter prototype. The new engine nacelles are clearly visible.



The much-enlarged nacelles of the Su-11 housed Lyul'ka TR-1 turbojets.

and rear false spars were bent to an inverted U-shape where the nacelles were mounted. To these the engines were hooked up from below and enclosed by ventral cowlings. The curved sections of the main spars were welded I-beams made of chromium steel thermally treated after assembly. The simple flaps were replaced by two-section slotted flaps with one section inboard and one outboard of each engine nacelle; each flap section moved on two tracks and was powered by a hydraulic ram. Because the thrust line had been moved up, the engine exhaust now impinged upon the stabilizer tips; to avoid this the horizontal tail was redesigned to incorporate 5° dihedral.

According to manufacturer's estimates the RD-10F-powered second prototype Su-9 was to have a top speed of 925 km/h (500.0 kts) at sea level and 908 km/h (490.81 kts) at 6,000 m (19,685 ft). Still, the aircraft was never built in this guise; when construction was well advanced it was decided to complete the second prototype as the next jet fighter from the Sukhoi stable – the **Su-11**.

Once again, this was the first aircraft to have this designation. Curiously, just like the first Su-11 was evolved from the first Su-9, the second Su-11 (manufacturer's designation T-45, NATO code name *Fishpot-B*) was a derivative of the second Su-9!

Bearing the in-house designation ***izdeliye* LK** (the L stood for Lyul'ka; ie, *izdeliye* K with Lyul'ka engines), the fighter was developed in accordance with the aforementioned Council of Ministers directive No. 952-397 dated 29th April 1946. As far as the general arrangement, structural design and armament were concerned, the Su-11 was almost identical to the Su-9. However, it incorporated the revised wing/nacelle arrangement and dihedral tailplane envisaged for the second Su-9. The powerplant was new, consisting of indigenous Lyul'ka TR-1 turbojets; thus, the Su-11 had 'run full circle', so to say, receiving the originally intended engines after all. This aircraft laid the foundation for a long and fruitful partnership between two outstanding Soviet aircraft engineers – Pavel O. Sukhoi and Arkhip M. Lyul'ka; a partnership which continues between the Sukhoi and Lyul'ka-Saturn companies to this day.

On 28th May 1947 the Su-11 made a ten-minute first flight at the hands of Gheorgiy M. Shiyanov. Once again, Sergey N. Anokhin also flew the aircraft at the manufacturer's flight test stage which involved 54 flights totalling 21 hour 8 minutes.

In the course of the tests the Su-11's aerodynamics were refined by lengthening the engine nacelles and revising the wing/nacelle fillets. Despite these improvements, the fighter could not meet the specified performance figures because it was underpowered, the pre-production TR-1s delivering only 1,300 kgp (2,866 lb st) instead of the required 1,500 kgp (3,306 lb st). With a 6,350-kg (13,999-lb) take-off weight, the Su-9 reached 940 km/h (508.1 kts) at sea level and 910 km/h (491.89 kts) at 3,000 m (9,842 ft); the service ceiling was 13,000 m (42,651 ft). The situation could not be remedied quickly because the 1,500-kgp TR-1A was still undergoing trials and was not yet flight-cleared.

Besides, despite the changes to the wing airfoils, longitudinal stability at high speeds was found to be inadequate and at Mach 0.75 the back pressure on the control stick was reversed, the stick moving forward and the aircraft tending to go into a dive. All of this eventually caused the Su-11 programme to be abandoned. The concluding part of the manufacturer's flight test report said: *'The unavailability of TR-1A engines and the insufficient effect of TsAGI's recommendations aimed at improving the aircraft's handling at high Mach numbers render further development work pointless.'*

On 3rd August 1947 the Su-11 also took part in the Tushino flypast with Gheorgiy M. Shiyanov at the controls. Later, the wings with their special curved spars were removed from the airframe and sent to TsAGI for structural strength testing.

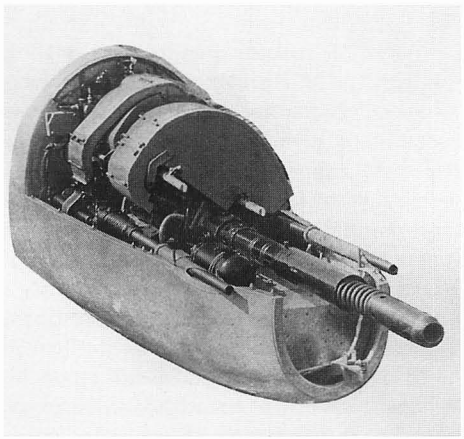
In 1947 the Su-11 served as the basis for yet another tactical fighter – the projected **Su-13**, aka ***izdeliye* TK**. Once again the main change was in the powerplant: the TR-1 engines were substituted by production RD-500 centrifugal-flow turbojets (the Soviet licence-built version of the Rolls-Royce Derwent V) rated at 1,590 kgp (3,505 lb st). The wings were reworked once again, featuring new airfoils with a thickness/chord ratio reduced from 11% to 9%, and sweepback was introduced on the horizontal tail. Two drop tanks could be fitted under the wingtips to extend range. The armament consisted of three 37-mm (1.45 calibre) Nudel'man N-37 cannons.

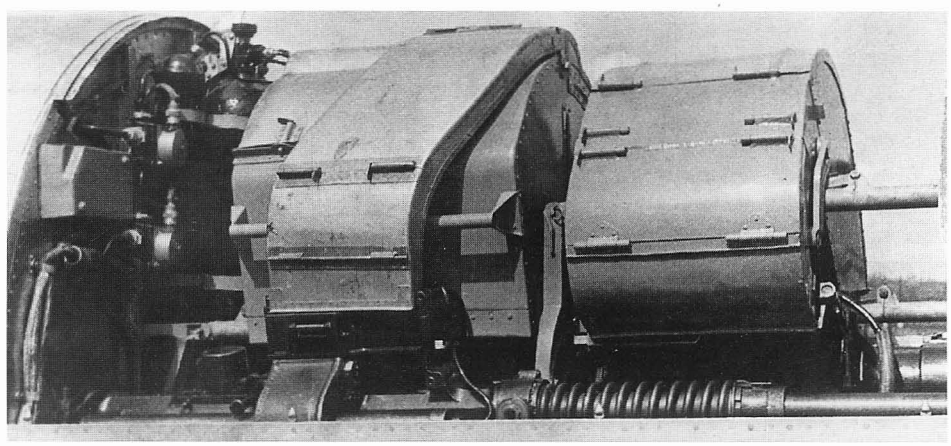
A **single-seat all-weather interceptor version** of the Su-13 was developed in parallel. The disappointing results shown by the Su-11 caused work on the Su-13 to be halted for several months; the engineers dusted off the interceptor project in March 1948, making several revisions at the same time. Among other things, the fuselage nose housed a Toriy (Thorium) radar developed by NII-17 (now the Moscow Research Institute of Instrument Engineering, aka NPO Vega-M) under chief project engineer A. B. Slepooshkin. The antenna dish was located between the barrels of the N-37 cannons. The addition of the radar led to major structural changes, requiring the cannon mounts, the forward fuel cell, the cockpit and the wings to be moved aft; also, wing area was increased to cater for the higher all-up weight.

Neither version of the Su-13 reached the hardware stage.

The following brief structural description applies to the Su-9.

Fuselage: One-piece stressed-skin monocoque structure with 33 frames connected





Two views of the Su-11's cannon installation; the ammunition boxes can be seen at the back of the weapons bay.

by four longerons. A special platform was incorporated into the forward fuselage structure for mounting the cannon armament. The forward fuel cell bay was located between it and the cockpit.

The centre portion of the fuselage housed the cockpit enclosed by a bubble canopy. The latter consisted of three parts – a fixed windshield, a sideways-hinged centre portion and a fixed rear portion; the windshield incorporated a bulletproof windscreen 90 mm (3.54 in.) thick. A transparent circular access panel was provided on the port side of the fuselage, allowing the canopy to be opened from the outside.

The rear fuel cell bay and the mainwheel wells were located behind the cockpit, with an avionics and equipment bay further aft. In addition to the bulletproof windscreen, the pilot was protected from the front by two 15-mm (0.59-in.) steel armour screens, an armoured seat back and headrest 12 mm (0.47 in.) thick and a 6-mm (0.23-in.) steel plate attached to the canopy above his head.

Wings: Cantilever low-mounted wings of trapezoidal planform utilising a TsAGI S-1-12 airfoil at the root and a TsAGI KV-3-12 airfoil at the tips. Dihedral 4°20', incidence 1°. Each wing was attached to the fuselage by four fittings and had a detachable tip fairing. A reinforced root rib was riveted to the fuselage and the wing skin was attached to it along the perimeter by bolts and anchor nuts to transfer the wing torque to the fuselage.

The wings were of single-spar construction, with front and rear false spars and stringers. The main spar was an I-beam; each spar flange was made of two duralumin angle profiles connected by a duralumin strip, while the spar web was made of duralumin sheet. The rear false spar was also made of duralumin sheet, with flanges and angle profiles riveted on for added stiffness; it was attached to the fuselage by a welded steel lug. Most of the wing ribs were of beam construction. The tip fairings were attached along the perimeter of the tip ribs by Allen screws.

Each aileron had a single spar and ten ribs of beam construction; it was skinned with duralumin sheet 0.8 mm (0.03 in.) thick. The inboard end of the port aileron incorporated a trim tab. The ailerons were mass-balanced; for this purpose a steel tube filled with molten lead was attached at the leading edge. Additionally, an angle profile was riveted on at the trailing edge of each aileron for aerodynamic balancing at high speeds.

The flaps were located between the fuselage and engine nacelles; each flap had two hinges and was actuated by a hydraulic ram. Additionally, split flaps were located between the engine nacelles and ailerons; these opened up and down to act as airbrakes but the lower portions could also be deflected independently, serving as outboard landing flap sections. The upper and lower halves of each airbrake had a maximum deflection of 57°30'.

Tail unit: Cantilever tail surfaces. The variable-incidence stabilizers were of all-metal stressed-skin construction with three spars, ribs and stringers. The tailplane spars were of channel and I section. The stabilizers were attached to the fuselage at the rear by two 15-mm (0.59-in.) bolts serving as hinges and at the front by the stabilizer trim mechanism. The single-spar stressed-skin elevators were both mass-balanced and aerodynamically balanced; the trim tabs were 100% mass-balanced.

The fin had two spars and a front false spar; the front and rear main spars were attached to the fuselage by two bolts and eleven bolts respectively. The all-metal rudder was of similar design to the elevators, featuring mass balancing and aerodynamic balancing and incorporating a trim tab.

Landing gear: Hydraulically retractable tricycle landing gear, with pneumatic operation in an emergency. The aft-retracting nose unit had twin 500x150 mm (19.68x5.9 in.) wheels; the nosewheel well was closed by a forward door attached to the oleo strut and twin lateral doors closed by mechanical links. The main units equipped with single 750x200 mm (29.52x7.87 in.) wheels retracted inwards, the wheels rotating through 90° around the oleo legs to stow vertically in the fuselage; the wheel wells were closed by doors attached to the oleo legs. Landing gear position was indicated by electric and mechanical indicators.

All wheels were equipped with pneumatically-operated drum brakes, the nosewheels featuring single-shoe mechanisms and the mainwheels having twin-shoe mechanisms. Two separate pneumatic systems worked the nosewheel and mainwheel brakes. A tail bumper consisting of rubber blocks was fitted to protect the rear fuselage in a tail-down landing.

Powerplant: Two RD-10 (Junkers Jumo 004B) axial-flow turbojet engines rated at 900 kgp (1,984 lb st) in underwing nacelles. The RD-10 had a fixed-area air intake, an eight-stage compressor, six individual combustion chambers, a single-stage turbine and a variable-section nozzle whose section was adjusted by a translating tailcone. The engine was mechanically started by means of a Riedel two-stroke two-cylinder engine; the main fuel was kerosene, but petrol was used for start-up as it was easier to ignite. The RD-10 was 3.935 m (12 ft 10.92 in.) long, with a casing diameter of 0.81 m (2 ft 7.89 in.), and had a dry weight of 720 kg (1,587 lb).

Each engine cowling consisted of an upper panel, two lower panels, two side panels and a tail fairing; they were held together by screw fasteners which were flush with the nacelle skin when closed. The tail fairing was made of 0.8-mm (0.03-in.) duralumin sheet; its trailing edge was made of spot-welded heat-resistant steel 0.5 mm (0.0196 in.) thick.

Two U-5 JATO bottles delivering 1,150 kgp (2,535 lb st) each for eight seconds could be installed under the fuselage for high gross weight take-offs. After burnout they were jettisoned by means of a special lock. The provision of JATO bottles reduced the take-off run by 30 to 40%.

Fuel system: The fuel system consisted of two bladder tanks located in the fuselage fore and aft of the cockpit, fuel transfer pumps, a fuel distribution/shutoff valve and piping.

Armament: Two 23-mm (.90 calibre) Nudel'man N-23 cannons with 100 rpg and one 37-mm (1.45 calibre) Nudel'man N-37 cannon with 40 rounds installed on a special mounting platform in the forward fuselage. Provision was made for the N-37 to be replaced with a 45-mm (1.77 calibre) cannon.

Two 250-kg (551-lb) FAB-250 high-explosive bombs (*foo**gahs**naya **avia**bom**ba*) or one 500-kg (1,102-lb) FAB-500 HE bomb could be carried on a faired rack under the forward fuselage; the rack was detachable and was installed just ahead of the wings. When bombs were carried the 37-mm cannon had to be removed.

Avionics and equipment: The Su-9 had a full complement of avionics and equipment as defined by the Soviet Air Force's general operational requirement for fighters issued in 1946.

The *oxygen equipment* included a 4-litre (0.88 Imp. gal.) oxygen bottle, appropriate piping, reduction valves and meters.

The *avionics* included an RSI-6M receiver and RSI-6 transmitter for air-to-ground/air-to-air communications, an RPKO-10 direction finder with an RMD loop aerial and an RV-2 radio altimeter.

A PBP-1P optical sight was fitted for firing the canons and performing dive-bombing and strafing attacks. Gunnery results were recorded by a PAU-22 gun camera. An AFA-NM aerial camera (***aero**foto**appa**raht***) was installed in the fuselage for vertical strip photography, enabling the Su-9 to perform some reconnaissance tasks as well (presumably it would be chiefly post-strike reconnaissance). The camera port was closed by inward-opening twin doors.

The specifications of Sukhoi's first jet fighters are indicated in the table on this page.

	Su-9 (*izdeliye* K)	**Su-9UT**	**Su-11 (*izdeliye* LK)**	**Su-13 (*izdeliye* TK)**
Powerplant	2 x RD-10	2 x RD-10	2 x Lyul'ka TR-1	2 x RD-500
Thrust, kgp (lb st)	2 x 900	2 x 900	2 x 1,300	2 x 1,590
	(2 x 1,984)	(2 x 1,984)	(2 x 2,866)	(2 x 3,505)
Length overall	10.546 m	10.546 m	10.546 m	10.93 m
	(34 ft 7.19 in.)	(34 ft 7.19 in.)	(34 ft 7.19 in.)	(35 ft 10.31 in.)
Height on ground	3.4 m	3.4 m	3.64 m	3.78 m
	(11 ft 1.85 in.)	(11 ft 1.85 in.)	(11 ft 11.3 in.)	(12 ft 4.8 in.)
Wing span	11.2 m	11.2 m	11.8 m	11.8 m
	(36 ft 8.94 in.)	(36 ft 8.94 in.)	(38 ft 8.56 in.)	(38 ft 8.56 in.)
Wing area, m^2 (sq. ft)	20.2 (217.2)	20.2 (217.2)	22.2 (238.7)	24.8 (266.66)
Empty weight, kg (lb)	4,060 (8,950)	3,600 (7,936)	4,637 (10,222)	4,055 (8,939)
All-up weight, kg (lb):				
normal	5,890 (12,985)	5,500 (12,125)	6,350 (13,999)	6,436.4 (14,189)
maximum	n.a.	n.a.	n.a.	7,036.4 (15,512)
Fuel load, kg (lb)	1,350 (2,976)	n.a.	n.a.	1,800 (3,968) [1]
Top speed, km/h (kts):				
at sea level	847 (457.83)	n.a.	940 (508.1)	960 (518.91)
at 3,000 m (9,842 ft)	n.a.	875 (472.97)	915 (494.59)	n.a.
at 4,000 m (13,123 ft)	n.a.	n.a.	n.a.	n.a.
at 5,000 m (16,404 ft)	885 (478.37)	n.a.	n.a.	960 (518.91)
at 8,000 m (26,246 ft)	880 (475.67)	n.a.	925 (500.0)	n.a.
Landing speed, km/h (kts)	150 (81.0)	n.a.	170 (91,89) [2]	n.a.
Climb time, minutes:				
to 5,000 m (16,404 ft)	4.6	5.7	3.2	n.a.
to 10,000 m (32,808 ft)	n.a.	n.a.	n.a.	6.5
Service ceiling, m (ft)	12,800 (41,994)	12,500 (41,010)	13,000 (42,651)	n.a.
Range, km (miles):				
normal	1,200 (745)	1,000 (621)	900 (559) [3]	1,550 (962) [4]
maximum	-	-	1,250 (776)	2,000 (1,242)
Endurance	1 hr 44 min	n.a.	n.a.	n.a.
Take-off run, m (ft):				
without JATO bottles				
with JATO bottles	910 (2,985)	n.a.	780 (2,559)	500 (1,640)
	475 (1,558)	n.a.	n..a	300 (984)
Landing run, m (ft):				
without brake parachute	960 (3,149)	n.a.	n.a.	500 (1,640)
with brake parachute	660 (2,165)	n.a.	n.a.	n.a.

Notes:

1. The fuel load with drop tanks is 2,350 kg (5,180 lb).

2. With a 5,550-kg (12,235-lb) landing weight.

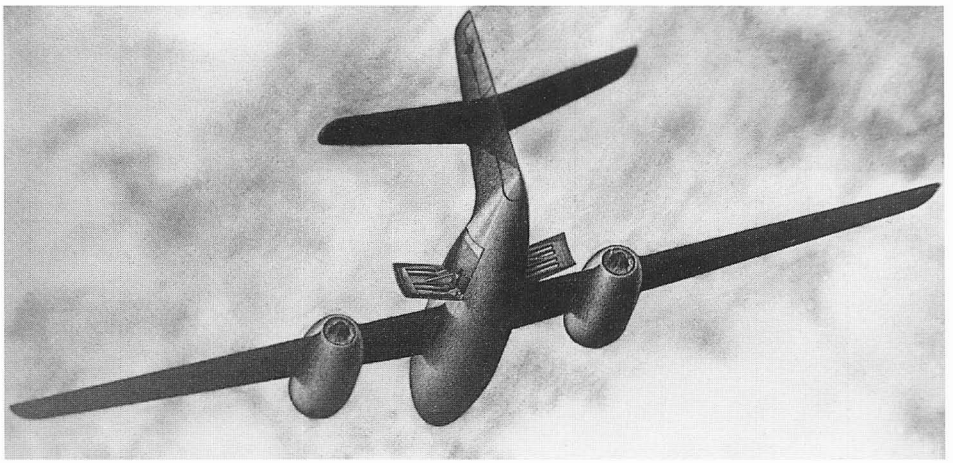
3. With a 6,237-kg (13,750-lb) all-up weight. Range with drop tanks and a 6,837-kg (15,072-lb) take-off weight is 1,250 km (776 miles).

4. With drop tanks.

Chapter 6

Alekseyev's Endeavour

Over the years the well-known Soviet aircraft designer Semyon Mikhaïlovich Alekseyev had supervised the development of various aerial vehicles; still, fixed-wing aircraft were always of prime importance for him. During the Great Patriotic War years Alekseyev had worked as Semyon A. Lavochkin's closest aide, participating actively in the development of the La-5 and La-7 fighters. In 1946 Alekseyev was appointed Chief Designer of aircraft factory No. 21 in Gor'kiy, working in this capacity until 1st September 1948. During the first post-war years the staff of OKB-21 (the design bureau of factory No. 21) developed a range of fighters, attack aircraft and short-range bombers; it should be noted that Alekseyev was one of the first among Soviet aircraft designers to start work on jet fighters.



An artist's impression of the I-21 featured in the advanced development project documents

As already mentioned, on 29th April 1946 the Council of People's Commissars issued a directive requiring several Soviet design bureaux to develop new jet fighters with more powerful engines than the captured German turbojets used originally. Hence in the spring of that year the Alekseyev OKB set to work on the **I-21** jet fighter (the I stood for *istrebitel'* – fighter, while the number was apparently a reference to OKB-21). The ADP stage was completed in August, and in mid-month the project was approved by S. M. Alekseyev and acting Director of the Gor'kiy aircraft factory Agadjanov.

The I-21 was a single-seat all-metal aircraft with mid-set unswept wings. The cruciform tail unit had a fin with a swept leading edge and a vertical trailing edge; the slightly swept stabilizers had noticeable dihedral. Two Lyul'ka TR-2 turbojets rated at 1,500 kgp (3,306 lb st) each were to be installed in wing-mounted nacelles. The engine cowlings were designed to provide easy access to the engines and permit quick engine change (the forward part of each nacelle could be easily detached, exposing the engine almost completely and allowing it to be extracted forwards).

Two armament options were envisaged: two 23-mm (.90 calibre) cannons and one 37-mm (1.45 calibre) cannon, or three 37-mm cannons developed by Nudel'man and Sooranov; all three cannons were installed in the fuselage nose. For strike sorties the fighter would carry two 250-kg (551-lb) bombs externally; additionally, two drop tanks, each holding 500 kg (1,102 lb) of fuel, could be fitted under the wings to extend range.

The I-21 was primarily intended for destroying enemy bombers and fighters, hence the heavy armament. The aircraft featured all the systems and equipment stipulated by the Soviet Air Force's general operational requirement for fighters in those days.

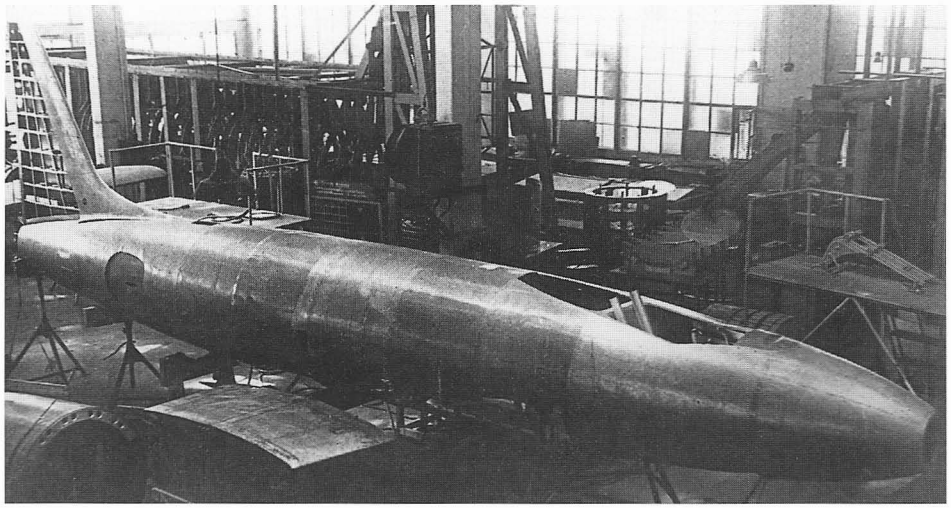
A priority task facing the I-21 design team was to achieve maximum possible range coupled with high speed, sufficient agility and adequate field performance. Hence the fighter's aerodynamics received special attention. The trapezoidal wings with an area of 25 m² (268.8 sq. ft) made use of laminar airfoils; so did the tail unit. The circular-section fuselage was also carefully streamlined. The aft fuselage incorporated an avionics/equipment bay with an access hatch on the port side and was flanked by lateral airbrakes which opened automatically when the aircraft reached its never-exceed speed; the fin was built integrally with the aft fuselage. The engineers paid special attention to minimising the harmful interference between the wings and the engine nacelles.

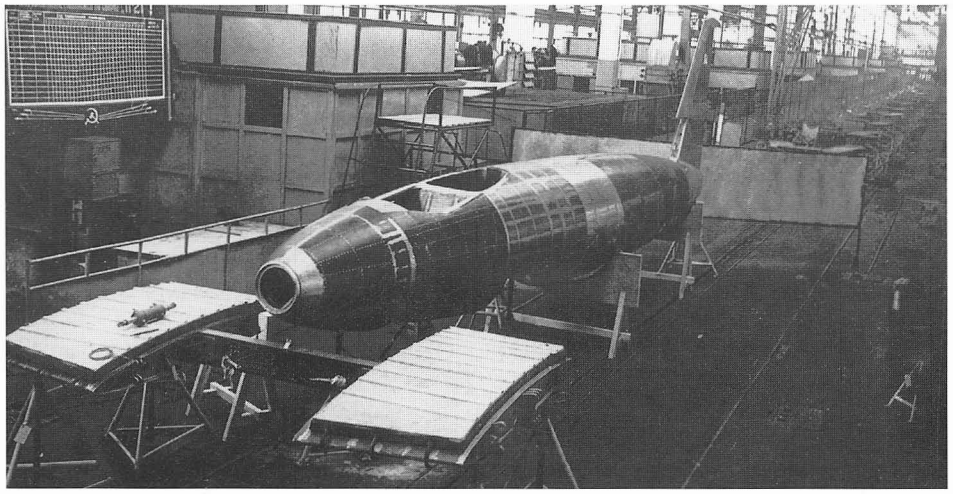
The I-21 had a hydraulically retractable tricycle undercarriage with twin wheels on each unit; the nose unit retracted aft and the main units inward to lie in the fuselage. All fuel was carried in four bladder tanks in the centre fuselage and the fuel load amounted to 2,500 kg (5,511 lb). The pilot sat in a pressurised cockpit equipped with an ejection seat and a jettisonable canopy opening to starboard; the location of flight instruments and control levers and switches was standard for Soviet fighters of the time.

To save structural weight the main load-bearing elements of the I-21's airframe were made of B-95 high-strength duralumin. High-strength steel was used in certain areas; additionally, some airframe components were to be manufactured of a magnesium alloy called *elektron*.

According to the advanced development project specifications the I-21 was to have a top speed of 980 km/h (529.72 kts) at sea level and 970 km/h (524.32 kts) at 5,000 m (16,404 ft), reaching this altitude in 2.4 minutes. The service ceiling was estimated at 13,000 m (42,650 ft). Cruising at the service ceiling, the fighter was expected to have a range of 2,300 km (1,428 miles) in 'clean' configuration and 3,000 km (1,863 miles) with drop tanks; maximum endurance was estimated at 4 hours. The design all-up weight was 7,100 kg (15,652 lb) in 'clean' configuration and 7,600 kg (16,754 lb) with drop tanks.

The project received the go-ahead and it was decided to build a flying prototype and a static test airframe. However, as had been the case with the preceding TR-1 which had begun bench testing in July 1946, the Lyul'ka OKB was experiencing development problems with the TR-2 and the development schedule was slipping. Therefore, as the next-best thing, OKB-21 engineers chose to fit the prototype with the less powerful TR-1 turbo-





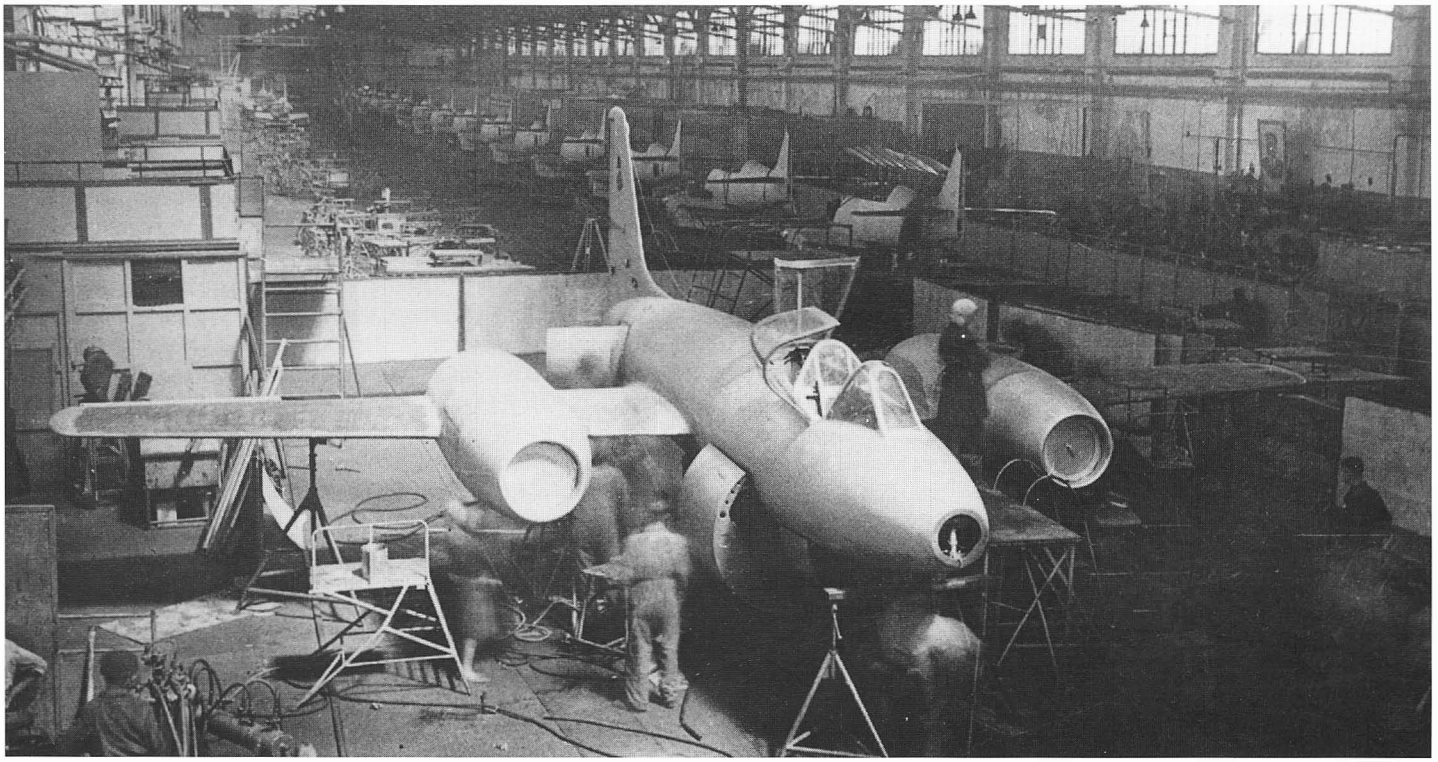
Top and above: The fuselage of the I-211 in various stages of assembly at the Gor'kiy aircraft factory.

jets delivering 1,300 kgp (2,866 lb st) until the intended TR-2 engines became available. The I-21 project had to be reworked accordingly, the engineers also envisaging the uprated TR-1A as a possible powerplant.

The aircraft was 11.54 m (37 ft 11.9 in.) long, with a wingspan of 12.25 m (40 ft 2.28 in.) and a wing area of 25.0 m² (268.8 sq. ft). The avionics fit was standard for the period and included an RSI-6 communications radio, an RPKO-10M DF and an SCh-3 IFF transponder.

Construction of two I-21 airframes – the prototype and the static test article – got underway at plant No. 21 at the end of 1946. The prototype was due for completion by 25th June 1947; the reason was that, like the jet fighter prototypes developed by other design bureaux, the aircraft had to be demonstrated in flight at that year's Tushino flypast where Soviet government and Communist Party leaders would be present. In the spring of 1947 the Minister of Aircraft Industry let loose with an order titled 'On the preparation of aircraft for the 18th August 1947 flypast', expressly requiring OKB-21 Chief Designer Alekseyev and Director of plant No. 21 Agadjanov to roll out the I-21 twin-engined fighter with TR-1 engines by 10th July and to complete initial flight testing by 1st August.

It should be noted at this point that the I-21 was developed in several versions at once. One of them was the **I-210** ('I-21, Version Zero', that is); it differed from the other versions in being powered by BMW 003 turbojets (as already mentioned, this engine was pro-



The almost finished airframe of the I-211 sits in a specially fenced-off area of the shop floor, with La-9 fuselaged on an assembly line in the background. Note the open weapons bay cover on the forward fuselage underside.

	CoPC directive	I-21 ADP project	I-211 ADP project version 1	I-211 ADP project version 2	I-211 manufacturer's flight tests
Powerplant	2 Lyul'ka turbojets	2 x Lyul'ka TR-2	2 x Lyul'ka TR -1	2 x Lyul'ka TR -1A	2 x Lyul'ka TR -1
Normal AUW, kg (lb)	n.a.	7,100 (15,652)	7,460 (16,446)	7,460 (16,446)	7,400 (16,314)
Maximum AUW, kg (lb)	n.a.	7,600 (16,754)	8,010 (17,658)	8,010 (17,658)	n.a.
Internal fuel load, kg (lb)	n.a.	2,000 (4,409)	2,000 (4,409)	2,000 (4,409)	2,000 (4,409)
Fuel load with drop tanks, kg (lb)	n.a.	2,500 (5,511)	2,500 (5,511)	2,500 (5,511)	2,500 (5,511)
Top speed, km/h (kts):					
at sea level	980 (529.72)	n.a.	n.a.	n.a.	950 (513.51)
at altitude, m (ft)	970 (524.32)/ 5,000 (16,404)	900 (486.48)/ 6,000 (19,685)	900 (486.48)/ 6,000 (19,685)	980 (529.72)/ 6,000 (19,685)	910 (491.89)/ 4000 (13,123)
Service ceiling, m (ft)	13,000 (42,650)	n.a.	n.a.	n.a.	13,600 (44,619)
Time to height, min:					
to 5,000 m (16,404 ft)	n.a.	2.4	5.0	3.8	3.0
to 10,000 m (32,808 ft)	n.a.	16.0	15.2	11.8	n.a.
to service ceiling	16.0	n.a.	n.a.	n.a.	n.a.
Range with drop tanks	2,800	2,300	1,800	2,000	1,550
at optimum cruise altitude, km (miles)	(1,739)	1,428)	(1,118)	(1,242)	(962)
Take-off run, m (ft)	820 (2,690)	820 (2,690)	n.a.	n.a.	800 (2,624)
Landing run, m (ft)	n.a.	1,460 (4,790)	n.a.	n.a.	900 (2,952)
Armament (cannons)	n.a.	1 x 37 mm w. 35 rounds	3 x N-37 w. 30 rpg	3 x N-37 w. 30 rpg	2 x 23 mm w. 75 rpg

duced in the Soviet Union as the RD-20). The engines were to be mounted in redesigned nacelles attached to the wing undersurface, as on the Su-9 described in the previous chapter. However, calculations quickly showed that the fighter would be unable to meet the stated maximum speed requirement with this powerplant. The engineers tried substituting the RD-20 with another axial-flow turbojet of German origin – the RD-10 (née Junkers Jumo 004), but this gave little effect and the I-210 was abandoned. As already mentioned, the TR-1 successfully passed its State acceptance trials in March 1947, whereupon a small pre-production batch of these engines was manufactured for delivery to the Soviet aircraft design bureaux and installation in development aircraft. Therefore OKB-21 selected this engine which offered higher thrust than both German turbojets.

Another straight-wing fighter was designed around two Klimov VK-1 centrifugal-flow turbojets and designated I-212. However, this was a two-seater and a very different aircraft thus will be dealt with later in this chapter.

Coming back to the I-21 now, the Gor'kiy aircraft factory managed to complete the flying prototype on schedule; nevertheless, the fighter did not make the Tushino flypast. Redesignated **I-211** (ie, I-21, Version 1), the aircraft entered flight test in the autumn of 1947, with A. A. Popov as project test pilot. A comparison of the fighter's estimated and actual performance is given in the table above.

The first six test flights showed that the I-211 not only surpassed the design performance figures for the TR-1 powered version but outperformed the Su-11 which was pow-

	ADP project	Manufacturer's flight tests
Normal AUW, kg (lb)	7,300 (16,093)	6,890 (15,189)
Maximum AUW, kg (lb)	7,850 (17,306)	n.a.
Fuel load, kg (lb):		
in 'clean' condition	2,300 (5,070) [1]	1,880 (4,144) [2]
with drop tanks	2,800 (6,172)	n.a.
Top speed, km/h (kts):		
at sea level	941 (508.64)	970 (524.32)
at altitude, m (ft)	n.a.	947 (511.89)/ 4,000 (13,123)
Time to height, min:		
to 5,000 m (16,404 ft)	3.0 [3]	2.96
to 10,000 m (32,808 ft)	8.0	n.a.
Range with drop tanks at optimum cruise altitude, km (miles)	2,500 (1,552)	n.a.
Take-off run, m (ft)	936 (3,070)	900 (2,952)
Landing run, m (ft)	400 (1,312) [4]	920 (3,018)
Armament (cannons)	3 x N-37 w 35 rpg	3 x N-37 w 35 rpg

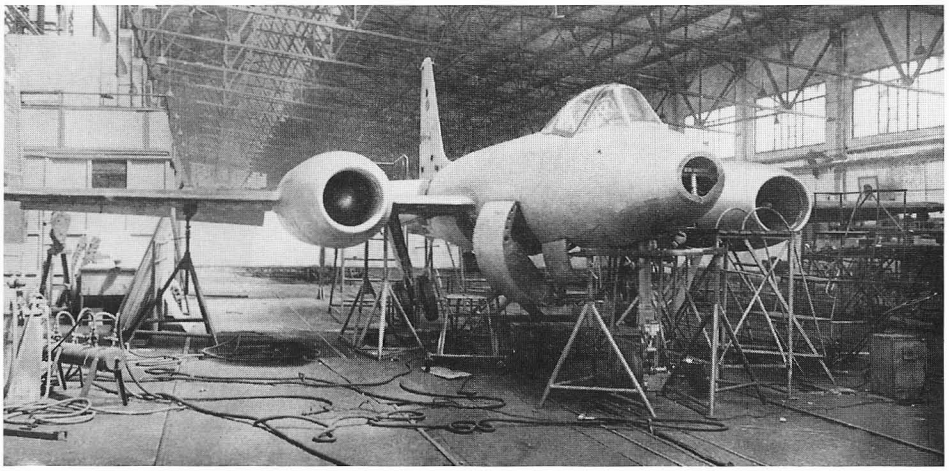
Notes:

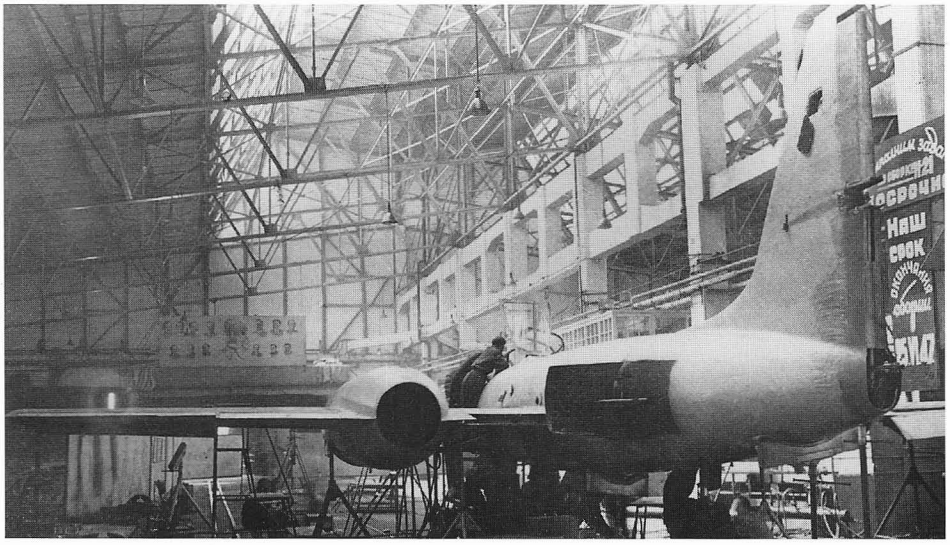
1. With drop tanks

2. Without drop tanks

3. The manufacturer's flight test report states an estimated climb time to 5,000 m of 2.6 minutes, not 3 minutes flat as in the ADP project.

4. With the flaps set at 45°.





Top and above: Two more views of the I-211 nearing completion. The placard in the lower picture urges the workers to complete the aircraft ahead of schedule.

ered by the same engines. Still, various events conspired against the I-211, preventing it from being tested in full. For one thing, one of the engines kept running roughly and there was no spare engine to replace it. For another, one of the flights ended in an accident when the fighter hit a pothole on landing, collapsing the landing gear. Apart from the undercarriage, the I-211 suffered only superficial damage; still, it was unflyable for the time being.

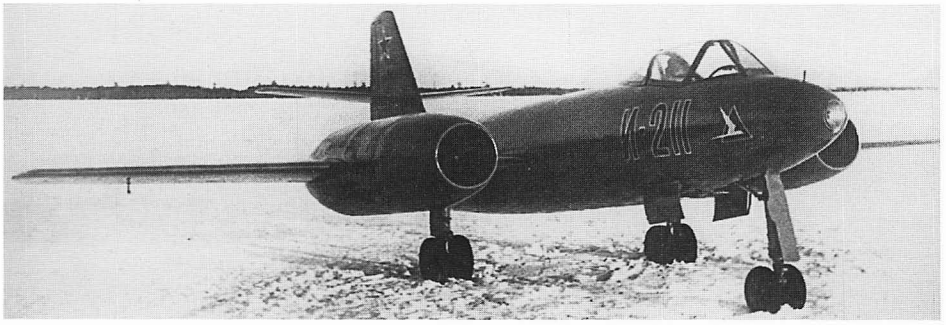
Anyway, the performance obtained in the autumn of 1947 was not good enough for the Soviet Air Force. As in the case of the Su-11, the unavailability of the more powerful TR-1A engines prevented the fighter from reaching the required top speed; besides, all of the Lyul'ka OKB's early turbojets (the TR-1, TR-1A and TR-2) never reached the production stage. Since the I-211 prototype had to be repaired anyway, it was decided at this stage to re-engine it with Rolls-Royce Derwent Vs with a take-off rating of 1,590 kgp (3,505 lb st).

As a matter of fact, advanced project development of the Derwent-engined version of the I-21 – designated **I-215** (for 'I-21, Version 5') – began a few months before the I-211 flew. All calculations were completed by mid-summer of 1947 and Chief Designer Semyon M. Alekseyev approved the project on 6th July. Yet another version designated **I-216** was developed in parallel; it differed in having exceptionally heavy armament consisting of two 75-mm (2.95-in.) cannons in the nose and in featuring modified outer wing panels. (**Note:** Some aviation researchers have suggested that the designation I-211 stands for 'I-21 with TR-1 engines' and the designation I-215 stands for 'I-21 with RR Derwent V engines'; however, the designation I-216 obviously does not fit this theory.)

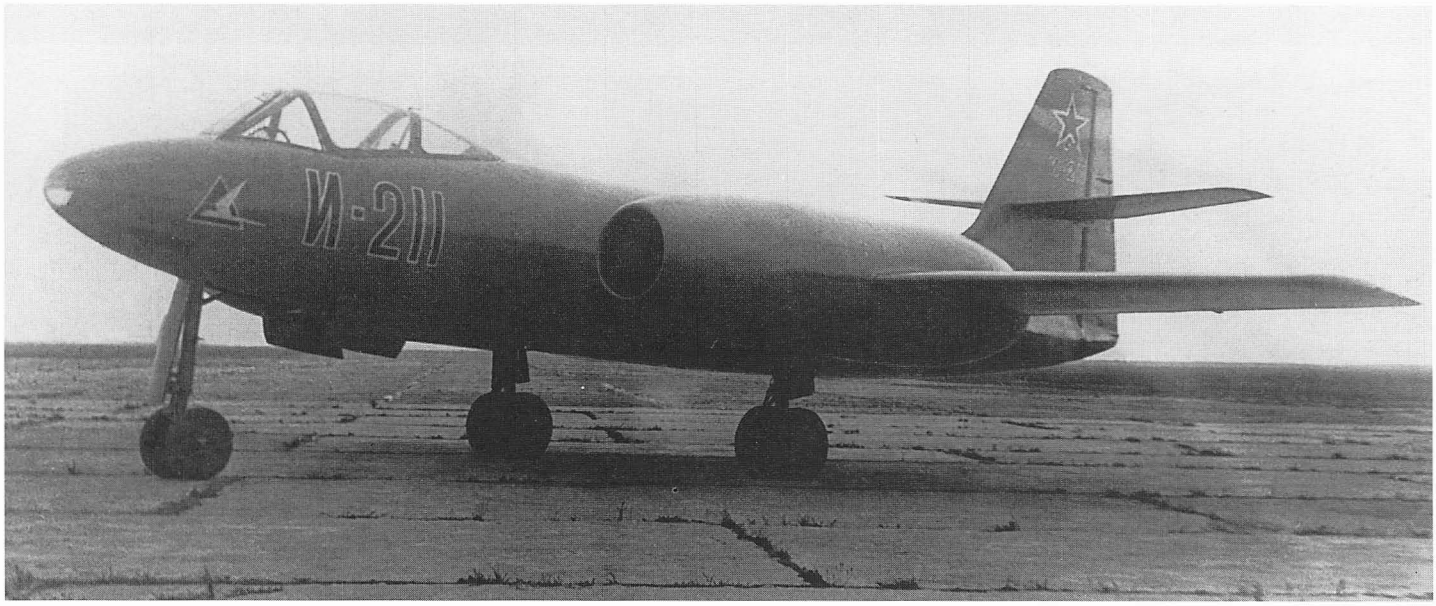
Of course, the I-215 was identical in dimensions and almost identical in appearance to its predecessor. The installation of Derwent V centrifugal-flow turbojets required the engine nacelles to be redesigned; changes were also made to the engine controls and the fuel system. The fuel load was increased to 2,300 kg (5,070 lb) by extending the rear fuel cell to aft and increasing the capacity of the lower forward fuel cell (to this end the fuel transfer pumps had to be relocated). Provision was made for a gun ranging radar in the nose, and a tail bumper was added under the rear fuselage to protect it in a tail-down landing. Besides, the I-215 featured an ammunition supply increased to 35 rpg, a thicker bulletproof windscreen and thicker front and rear armour sheets in the cockpit.

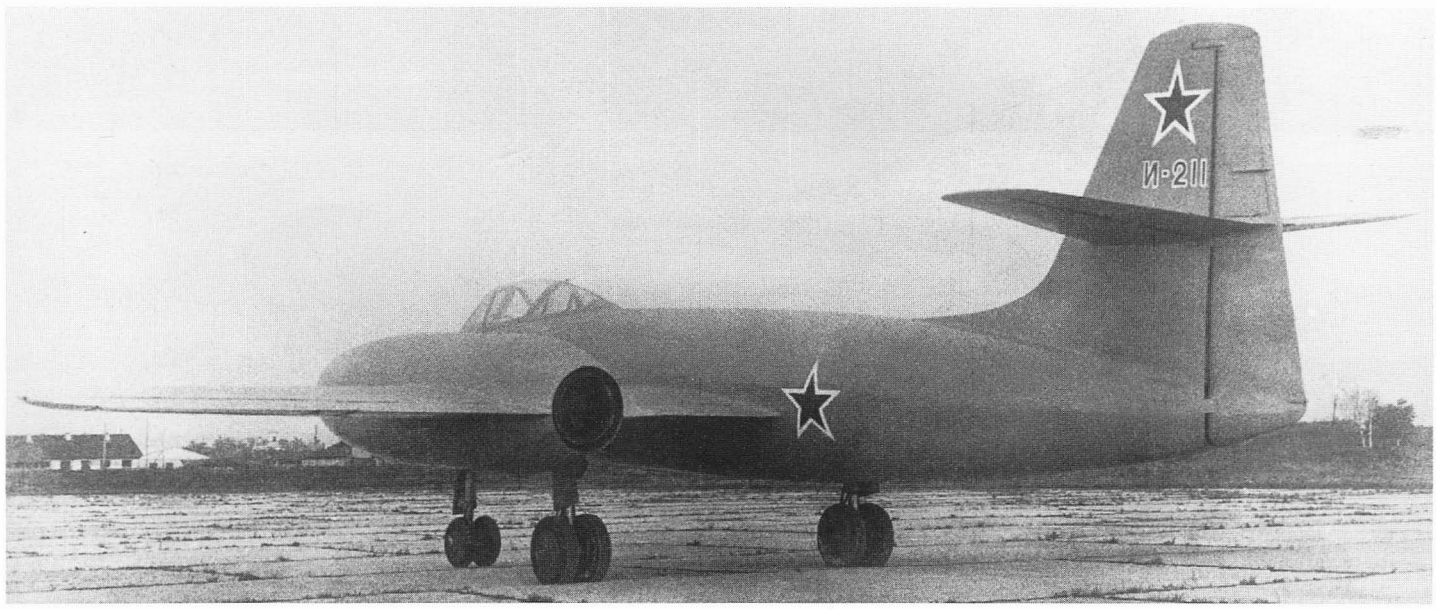
Repairs of the I-211 and its conversion to the I-215 prototype at plant No. 21 were completed in late 1947. Between 18th April and 20th June 1948 the fighter underwent manufacturer's flight tests; as had been the case with the I-211, factory test pilot A. A. Popov was appointed project test pilot. The test programme involved 26 flights; besides Popov, test pilots A. A. Yefimov, Sergey N. Anokhin and Mark L. Gallai also flew the aircraft. The I-215's performance is detailed in the table at the bottom of page 123.

Despite a number of shortcomings, generally the I-215 met its design specifications; the fighter earned praise from the pilots who flew it and was recommended for State acceptance trials. Still, the scenario was repeated: by mid-1948 the fighter could no longer meet the Air Force's growing requirements and thus stood no chances of entering service. Powered by the same RR Derwent V engine, the Yak-23 light fighter which had entered production was was only marginally slower than the I-215, yet more agile and possessed a better rate of climb. The Alekseyev OKB's fighter had markedly longer range than the Yak-23, but little good did it do; like all the other straight-winged experimental fighters, the I-215 fell victim to the finest Soviet fighter

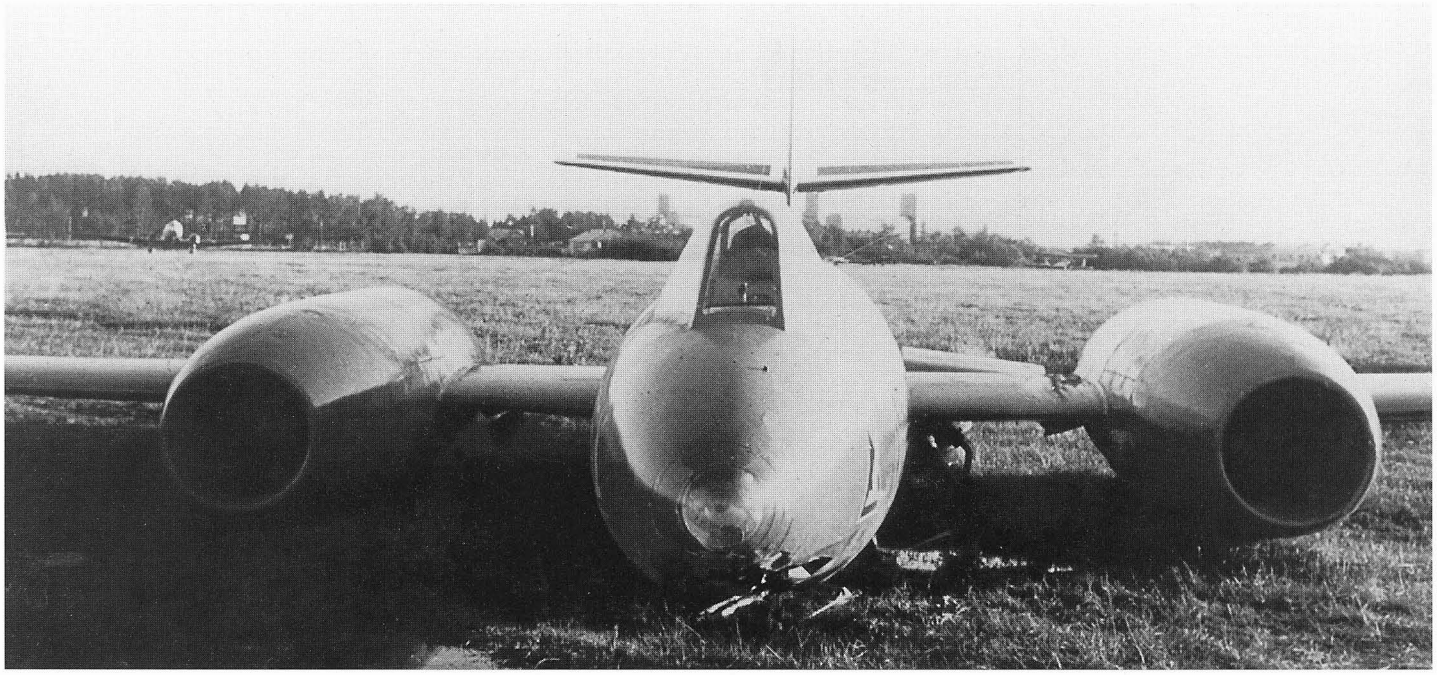


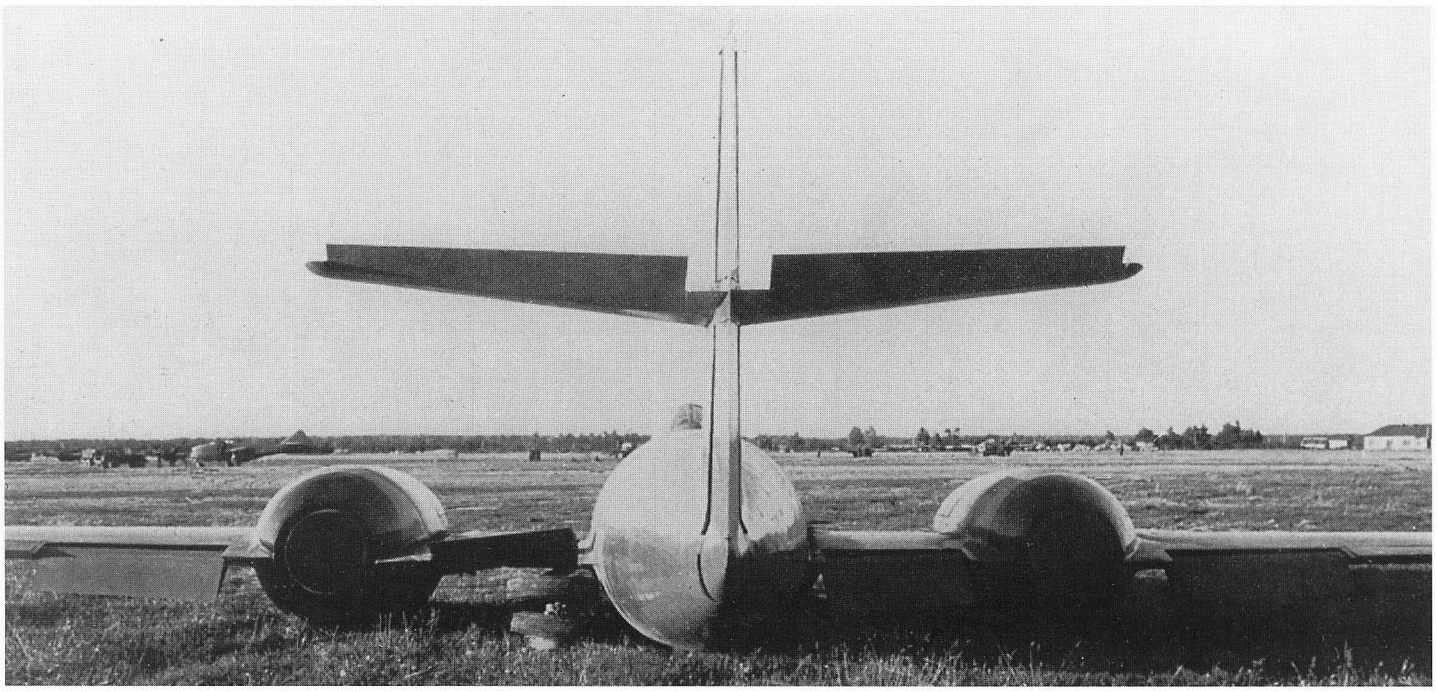
The I-211 seen during trials in the winter of 1947-48.

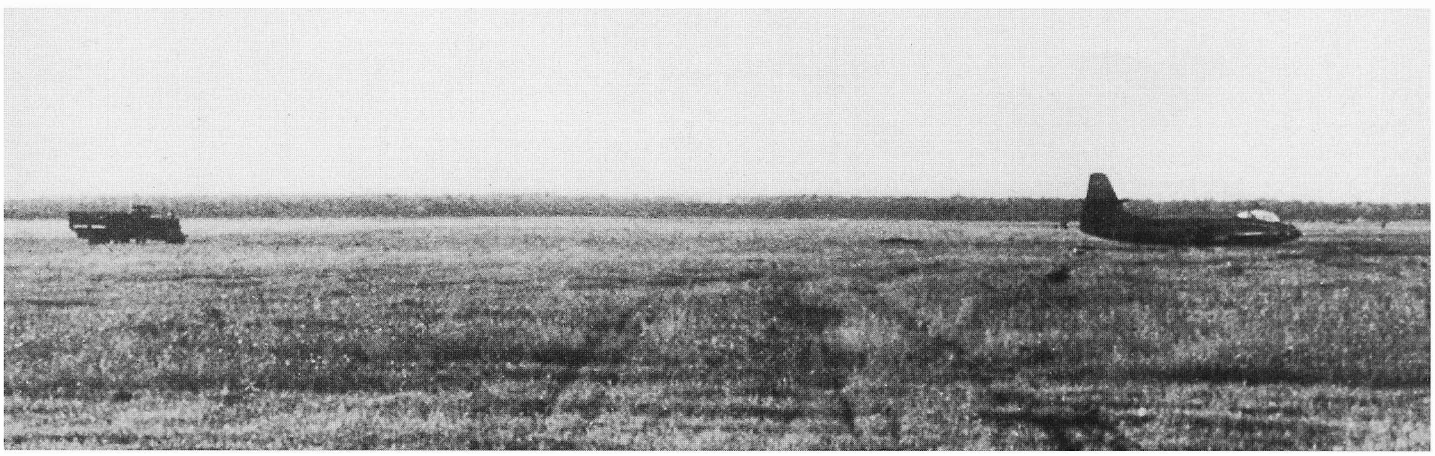




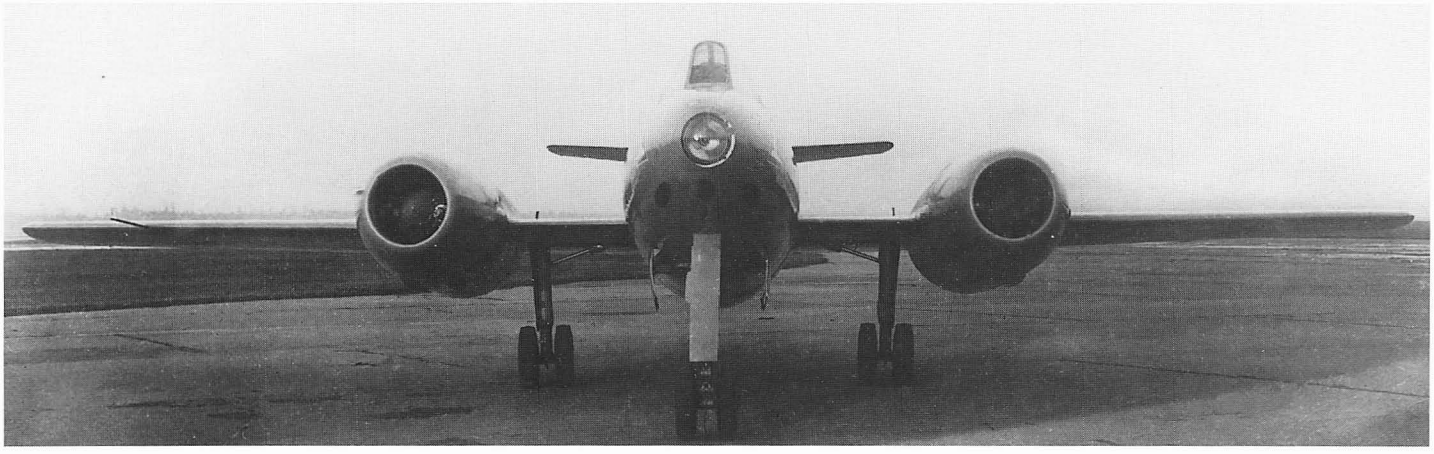
Three views of the I-211 during manufacturer's flight tests. The aircraft type was writ large on the nose and the tail.





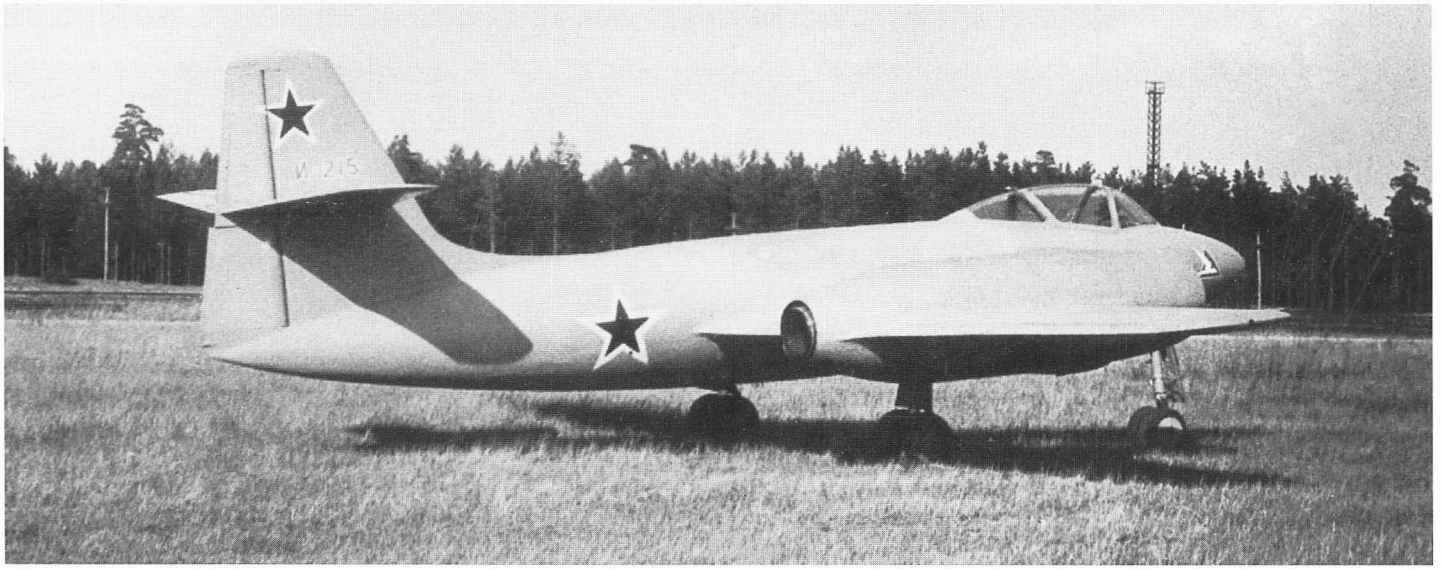


These photos show the I-211 after a crash landing.

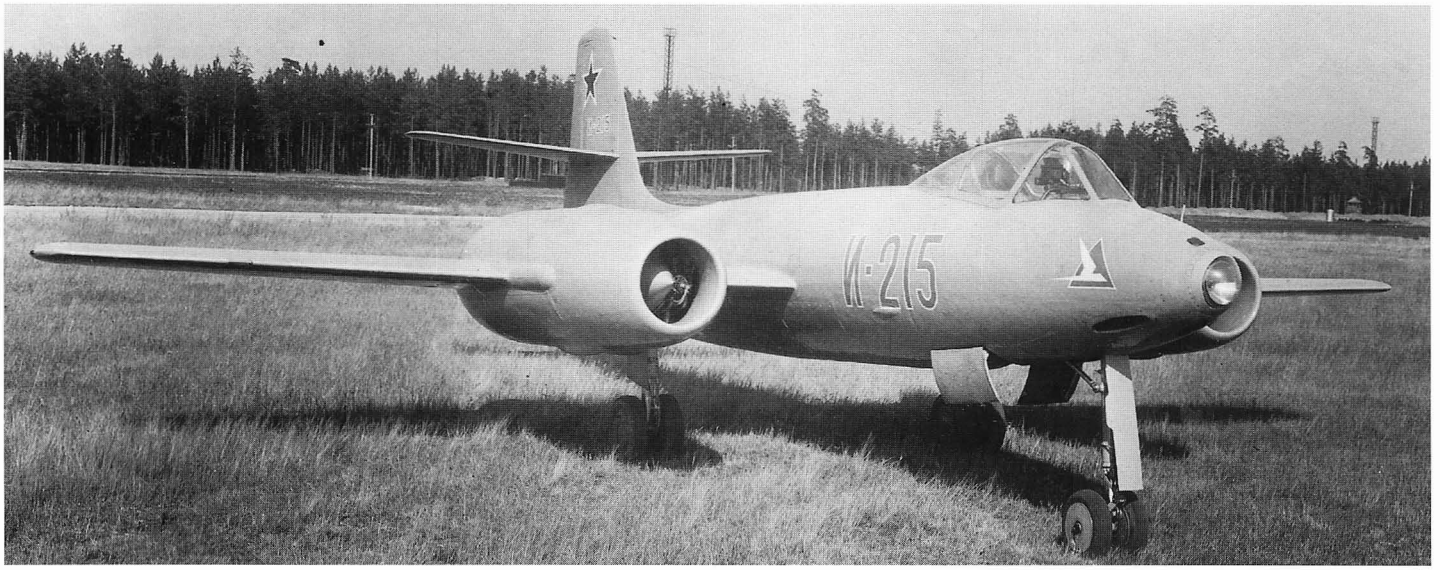


The photos on this page show the same aircraft following repairs and conversion to the I-215 prototype.

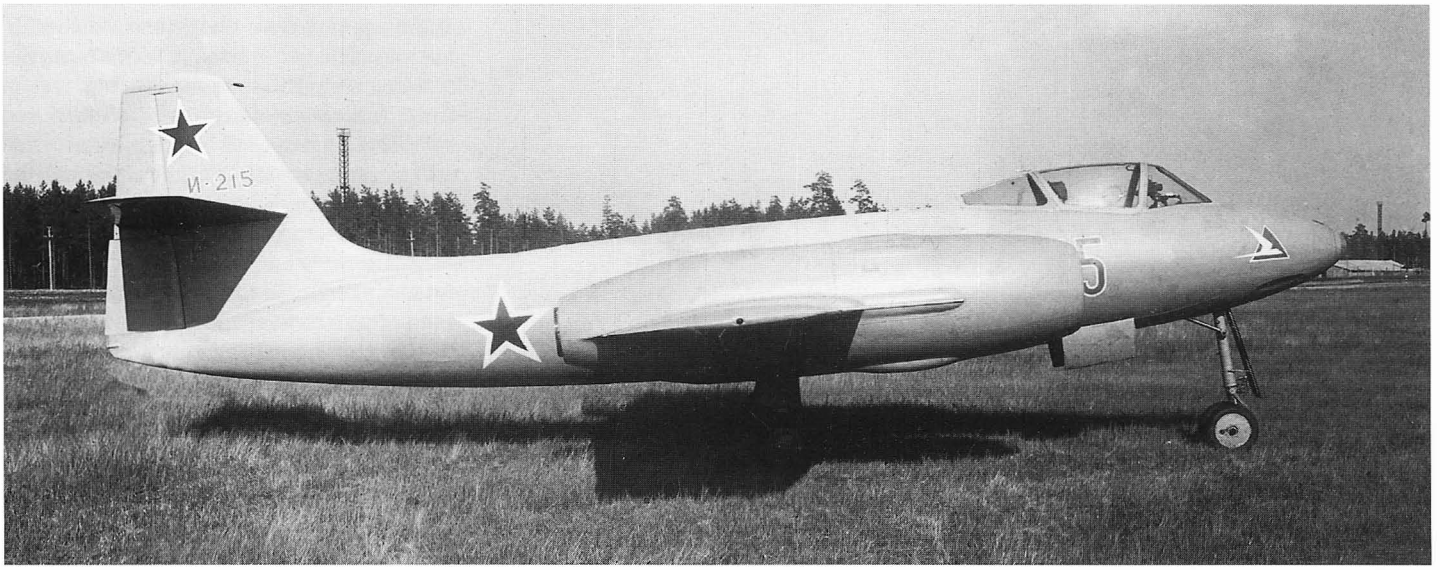
Above: The I-215 seen at NII VVS with a ground power unit connected for engine starting.



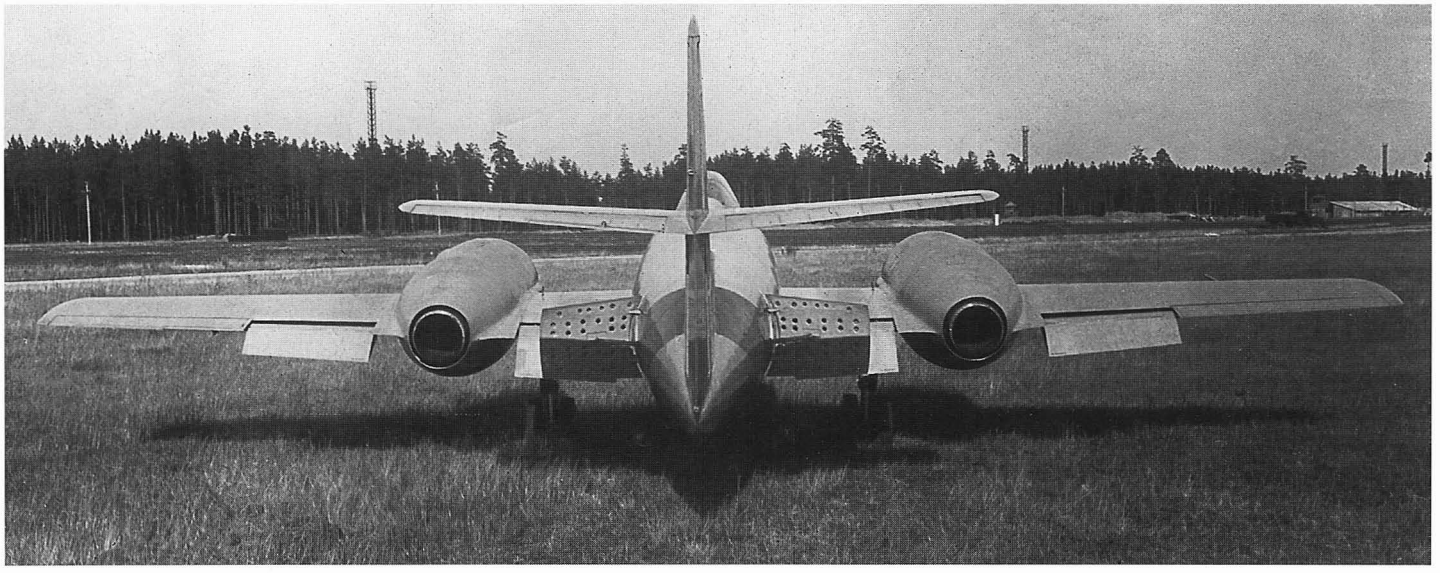
Above and below: Two more views of the I-215 during State acceptance trials.



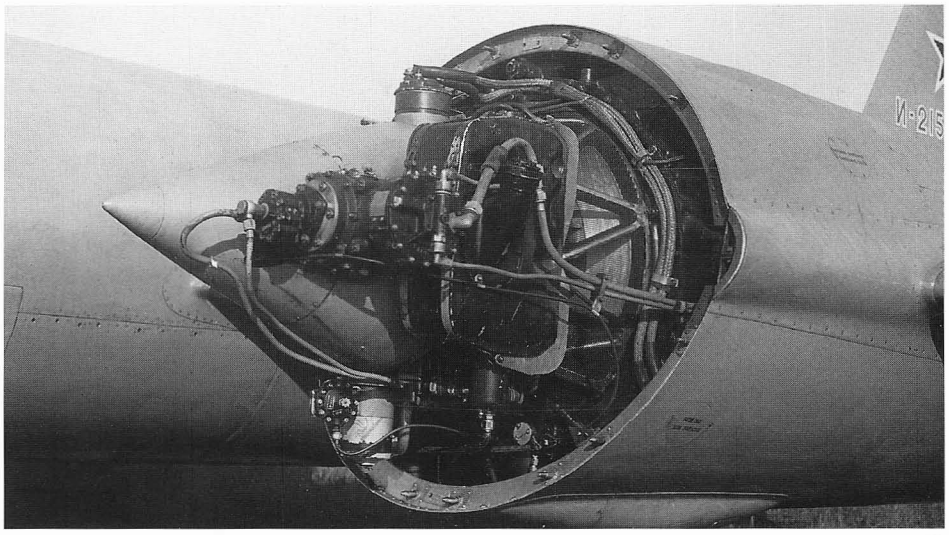
Above: Like the I-211, the I-215 had no serial but proudly carried the designation on the nose and tail. The emblem on the nose was that of OKB-21.



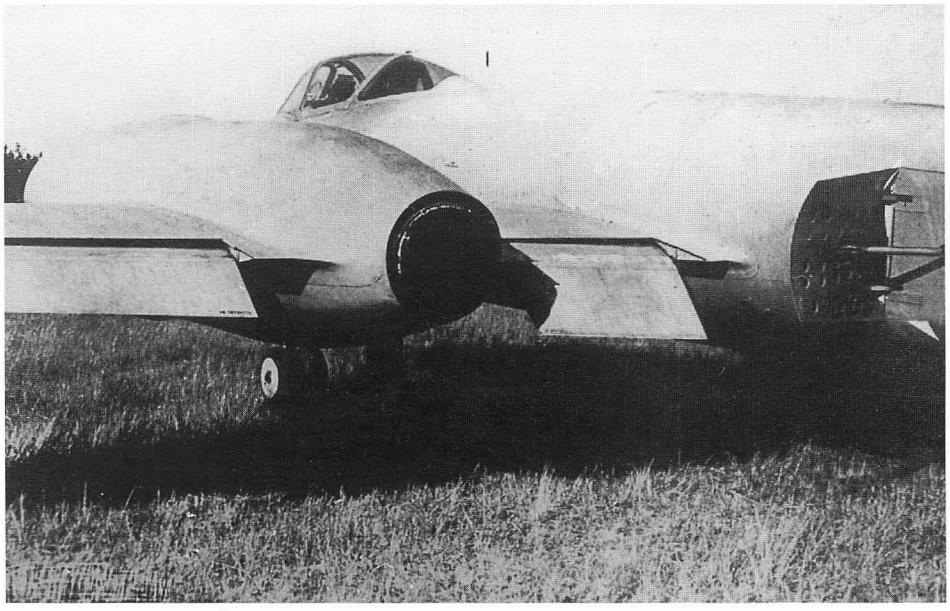
Above: Despite having basically the same general arrangement, the I-211/I-215 certainly was not a 'Me 262 look-alike', bearing more resemblance to the Gloster Meteor.



This rear view of the I-215 at GK NII VVS clearly shows the large airbrakes and two-section slotted flaps.



Above: The port engine nacelle with the cowling section removed, showing the front end of the RR Derwent V engine.



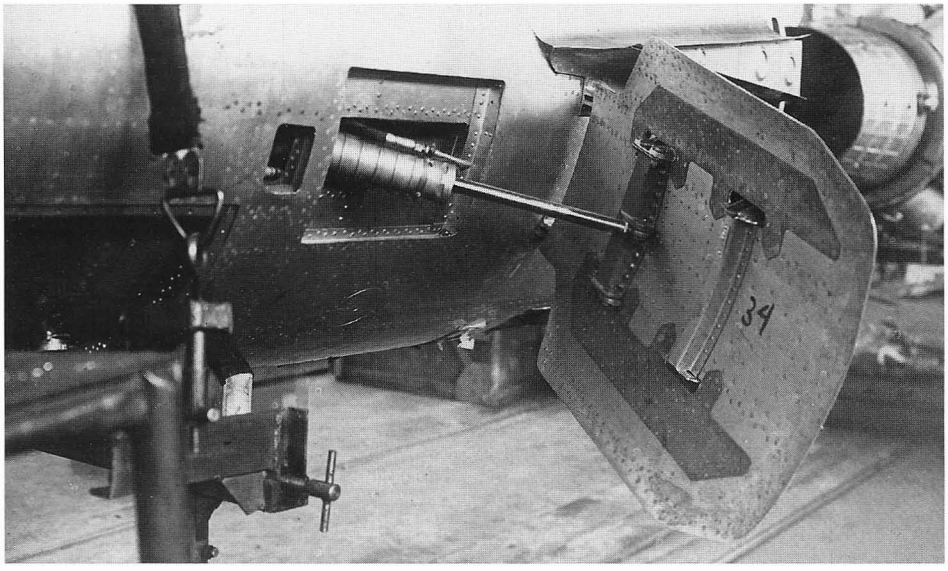
Above: Close-up of the I-215's flaps and port engine nozzle.

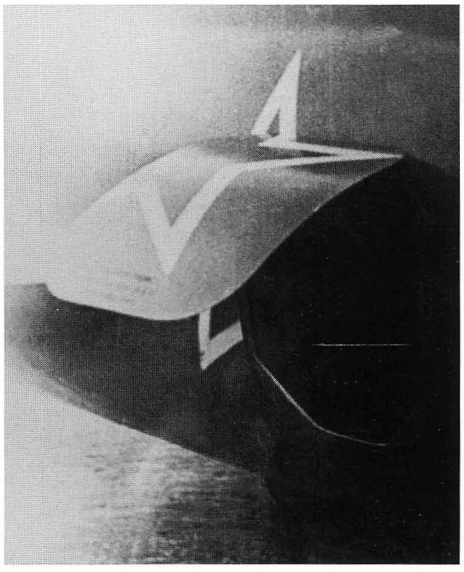
of the time – the swept-wing MiG-15 which shattered the hopes of many design bureaux.

Nevertheless, a second example was built. Bearing the designation I-215D (*doob-**lyor*** – second prototype), it differed considerably from the first I-215, being, as it were, custom-built to fill a special order placed by OKB-1. Based at MAP plant No. 256, this design bureau was staffed with captive German engineers supervised by Dr. Brunolf Baade. The I-215D was built to verify the novel bicycle landing gear arrangement envisaged for several Soviet combat aircraft, including the 'aircraft 150' twinjet medium bomber then under development at OKB-1.

The main landing gear units were placed fore and aft of the aircraft's entre of gravity. The rear strut incorporated a 'kneeling' feature to increase the angle of attack on take-off by 3°. The outrigger struts retracted aft into the lower portions of the engine nacelles; when the landing gear was extended the outrigger wheels were almost in line with the CG. The wings had an incidence of 3°30'; together with the aforementioned 'kneeling' feature this provided an adequate angle of attack and sufficient lift for take-off. Hence, unlike aircraft with a conventional tricycle landing gear, the I-215D could become airborne without rotation, not requiring the pilot to haul back on the control stick.

Many of the Soviet aircraft engineers and airmen were opposed to the bicycle landing gear at the time, claiming it was 'inherently unsafe'. However, Semyon M. Alekseyev graphically demonstrated with the help of the I-215D that these fears were unfounded. The freshly completed I-215D stood on the factory apron, perfectly airworthy and ready for its first flight. Test pilot I. Ye. Fyodorov, Hero of the Soviet Union, agreed to ferry the aircraft to the flight test facility of OKB-1 (to which Alekseyev had been transferred by then). The





Above, details of the I-215's starboard airbrake, with hydraulic actuator and reinforcing plates; right, the avionics bay was accessed via a hatch on the port side of the rear fuselage.

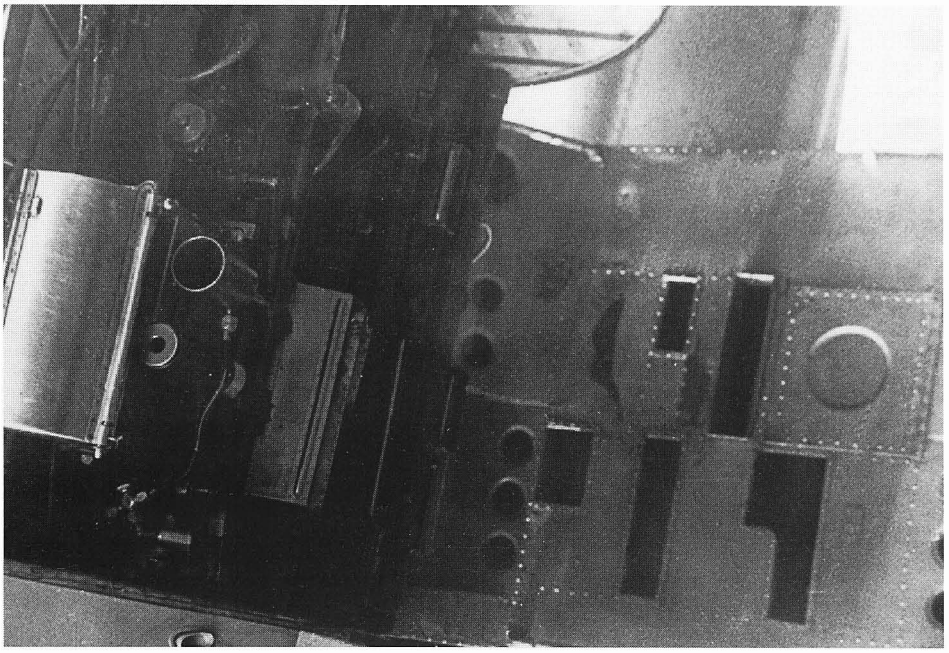
flight, which involved a refuelling stop at LII's airfield (then referred to as Ramenskoye airfield), took place in October 1949 (the exact date is unknown) and went perfectly. On arrival the pilot put on a brief aerobatics display with steep banking turns; after landing he did several sharp turns and figure-eights at maximum taxiing speed, showing that an aircraft with a bicycle landing gear could manoeuvre safely on the ground with no tendency to tip over on one wing.

To conclude the story of Alekseyev's twin-jet fighters a brief mention should be made of the projected **I-212** two-seat fighter (ie, 'I-21, Version 2'). Development was initiated in the spring of 1947 and Semyon M. Alekseyev approved the ADP project on 14th May.

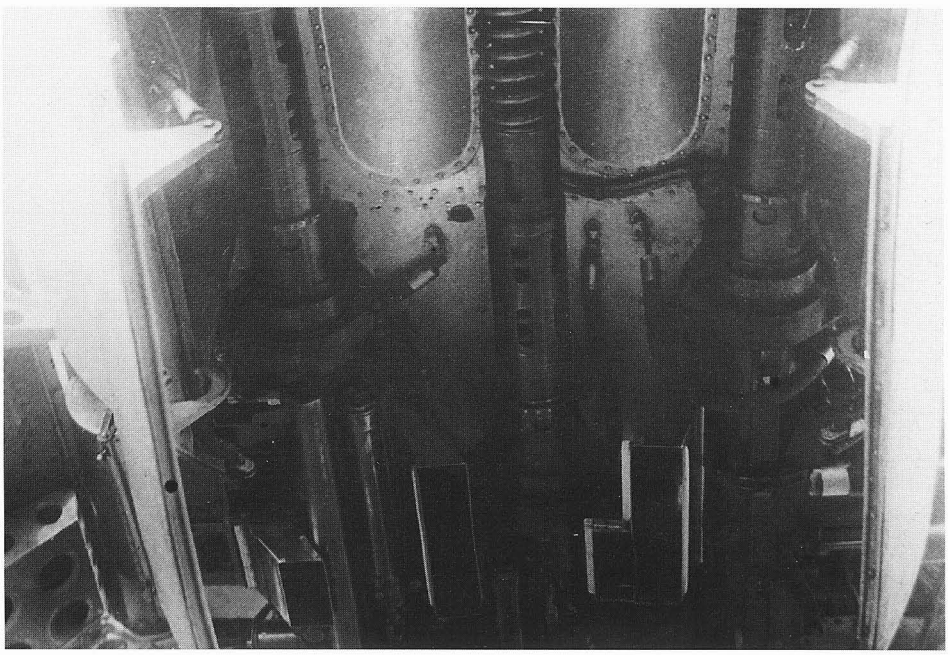
As already noted, the I-212 was designed as a two-seat all-metal mid-wing fighter with two wing-mounted VK-1 centrifugal-flow turbojets. The general arrangement was similar to that of the I-211/I-215, except that sweepback on all tail surfaces was markedly increased. The armament consisted of four fixed 23-mm Nudel'man/Sooranov NS-23 cannons with 150 rpg in the fuselage nose and two 20-mm (.78 calibre) G-20 cannons in a remote-controlled tail barbette, also with 150 rpg. An alternative weapons fit comprised two NS-23s with 150 rpg plus one 45-mm (1.77 calibre) NS-45 cannon with 40 rounds in the nose and two more NS-23s in the tail barbette. The fighter featured the latest avionics, including radar, and pressurised cockpits for the pilot and gunner/radio operator. Though the I-212 was conceived as a long-range escort fighter, its design performance allowed it to be used in the night fighter and reconnaissance roles as well.

In designing the I-212 the engineers of OKB-21 attempted to come as close as possible to the Air Force's requirements and to achieve maximum speed and range. The pilot and gunner/radio operator sat in tandem, back to back, under a common canopy designed for low drag and unrestricted visibility in both front and rear hemispheres; the cockpits were accessed via sideways-hinged canopy sections. Both crew members were protected by 60-mm (2.36-in.) bulletproof windshields, a 10-mm (0.39-in.) forward armour plate and an 8-mm (0.31-in.) rear armour plate; the fuel tanks also offered some protection, as they were designed not to explode when pierced by cannon shells. Both cockpits featured cartridge-fired ejection seats; the crew escape system was designed so as to preclude the danger of the seats colliding in the event of a simultaneous ejection.

The fuselage shape, length and cross-section area were optimised for housing a large amount of fuel, all three landing gear units, the armament, avionics and equipment while creating minimum drag. The trapezoidal



Above: The cannons' breeches, seen from the left; note the spent case chutes in the weapons bay cover.



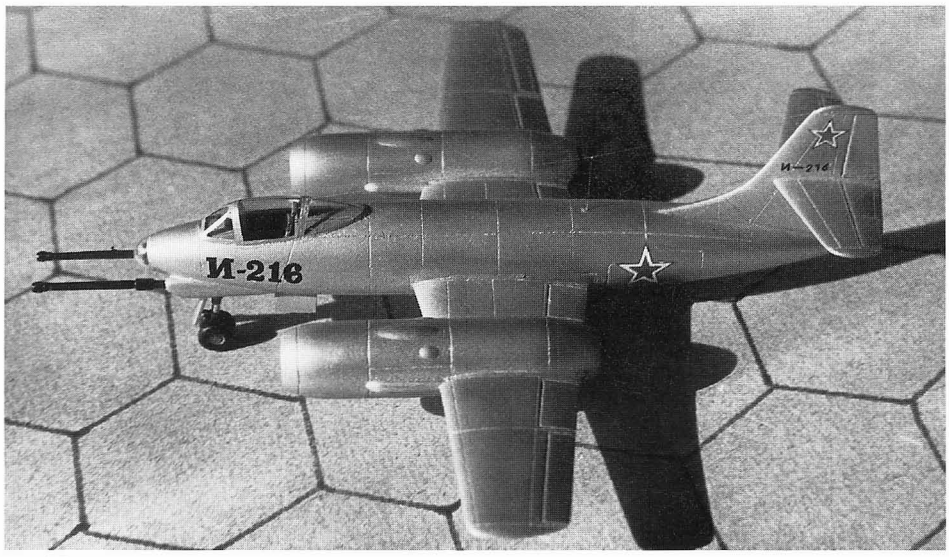
The barrels of the three cannons can be clearly seen through the nosewheel well doors; note the recesses for the wheels at the top of the picture.

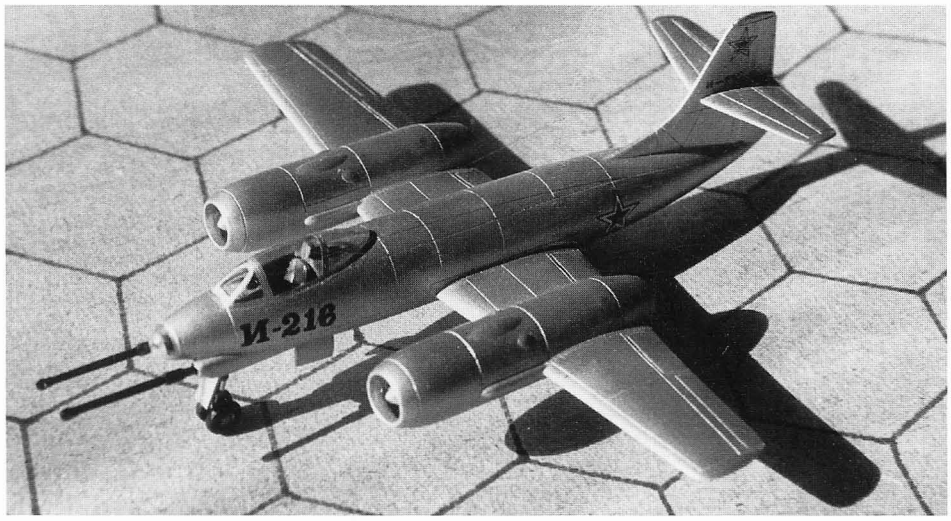
wings made use of TsAGI laminar airfoils; the mid-set position of the wings with respect to both fuselage and engine nacelles was chosen in order to minimise harmful interference.

As already mentioned, the I-212 was designed around two VK-1 turbojets rated at 2,200 kgp (4,850 lb st) for take-off. However, this engine was still on the drawing board in 1947, so as an insurance policy the engineers of OKB-21 considered a version powered by the less powerful RD-45 engines (a copy of the RR Nene which was entering licence production in the USSR at the time). As had been the case with the I-211/I-215, the nacelles were designed to provide easy access to the engines and speedy engine change.

The fuel cells were positioned in such a way as to minimise the CG shift when fuel was burned off. Additionally, the I-212 featured 'wet' wing hardpoints for carrying two drop tanks, each holding 550 kg (1,212 lb) of fuel, or two 500-kg (1,102-lb) bombs. If external stores were carried, JATO bottles were to be fitted to shorten the take-off run.

The avionics suite included the Toriy (Thorium) radar, an IFF transponder, communications radios, a radio altimeter, a DF and a Ton-3 (Tone-3) radar warning receiver (RWR)





Above and below: A model of the I-216, a derivative of the I-211 with two large-calibre cannons. Note the long barrels projecting far beyond the nose.

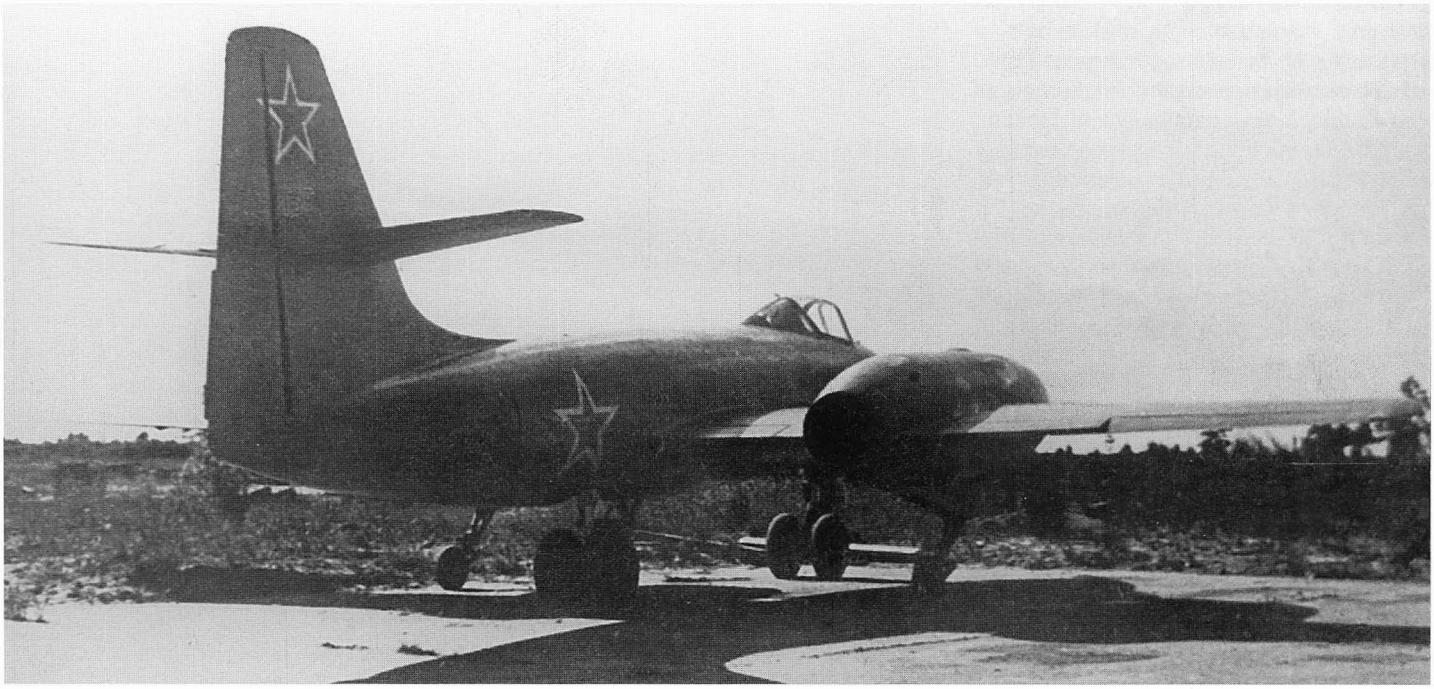
covering the rear hemisphere. The gunner/radio operator also worked the Toriy radar; thus it would be more accurate to call him a radar intercept officer (RIO).

To cut empty weight and maximise the payload-to-weight ratio while providing adequate structural strength the main load-bearing components of the airframe were to be made of high-strength steel and V-95 high-strength duralumin. Numerous airframe components were to be made of elektron magnesium alloy sheet and castings.

According to manufacturer's estimates the I-212 would have a normal all-up weight of 9,250 kg (20,392 lb) and a maximum AUW of 10,500 kg (23,148 lb); top speed would be 1,000 km/h (540.54 kts) at sea level and around 960 km/h (518.9 kts) at 8,000 m (26,246 ft). The estimated service ceiling with a normal AUW was 14,000 m (45,931 ft) and maximum range with drop tanks was to be 3,100 km (1,925 miles). A training version designated **UTI-212** (*oo**cheb**no-treni**rov**och-nyy istre**bit**el'*) was also planned.

Like many promising aircraft developed by OKB-21, the I-212 never got beyond the drawing board. This was because so many experimental combat aircraft were built and tested in the Soviet Union in the late 1940s, and the Soviet Air Force, having many types to choose from, had no need for more. Still, the choice was soon narrowed to a few types, since many of these experimental aircraft could not meet the Air Force's demands and hence did not enter service.

Finally, mention must be made of the projected **I-217** (ie, 'I-21, Version 7') which was developed in two versions (with sweptback and forward-swept wings).



The I-215D development aircraft with a bicycle landing gear.

This late-production MiG-9 (c/n 114010) is on display at the Central Russian Air Force Museum in Monino.

Yak-15 '37 Yellow', the only example surviving in Russia, is seen here at Moscow-Khodynka in August 1989 during the Aviation Day display

Yak-17 '02 Red' in its latter days at Monino in a non-authentic colour scheme. The aircraft was originally light grey with a white lightning bolt.

This rare Chinese MiG-9 is preserved at the People's Liberation Army Air Force Museum at Datangshan AB.

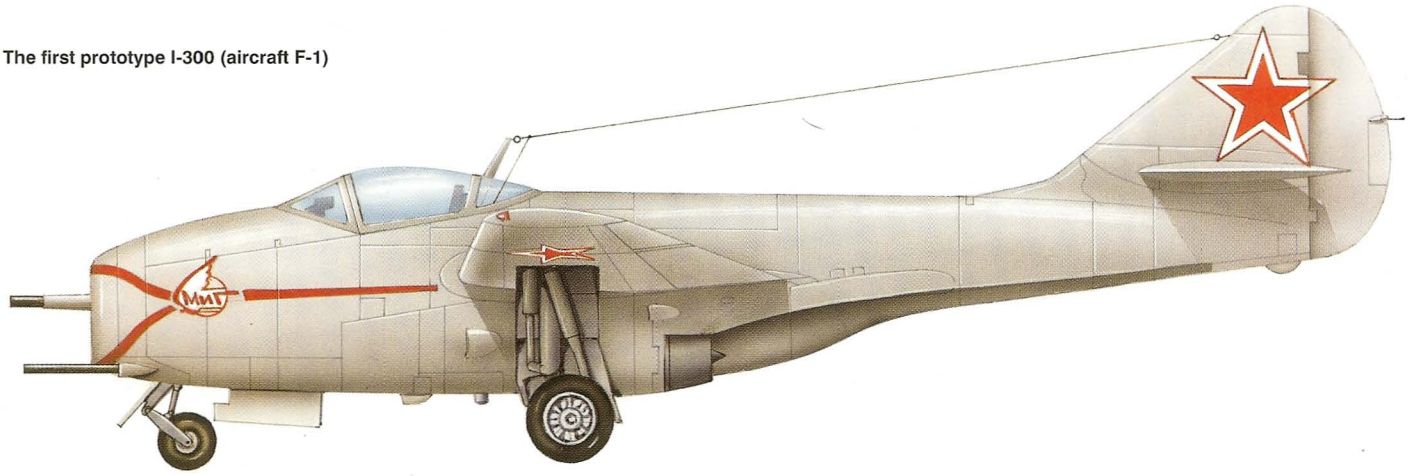
Another first-generation Soviet jet in PLAAF markings. This Yak-17UTI is also on display at Datangshan.

Yak-23 '15 Red' in the open-air display at Monino. The rear part of the canopy transparency has been damaged and hastily mended with sheet metal.

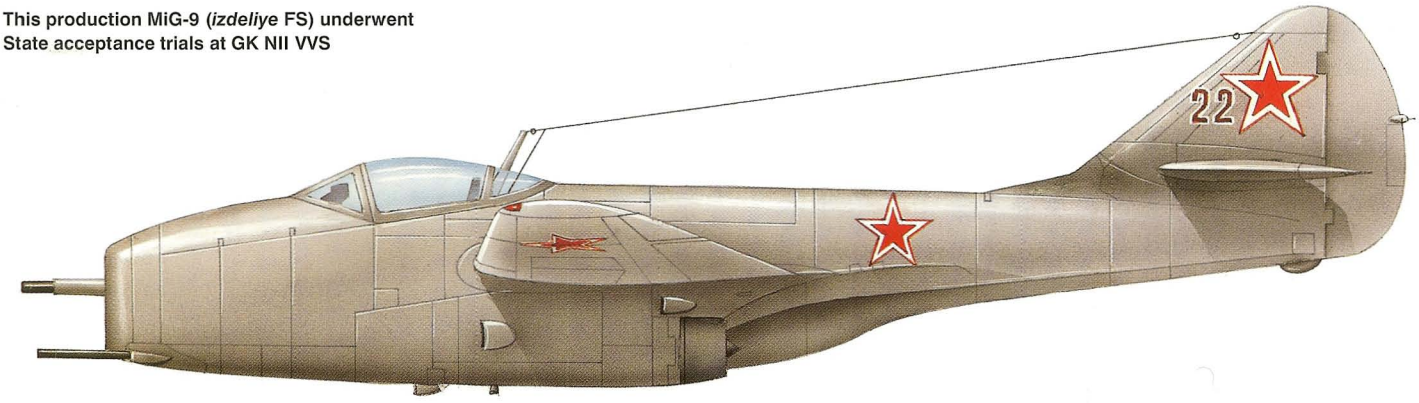
Above and below: Miraculously preserved in the Yakovlev OKB, the sole UTI Yak-23 is seen here at Moscow-Khodynka in September 1993 during the MAKS-93 airshow. Note that the rear canopy has been replaced by a non-original one.

06, a very weather-stained Polish Air Force Yak-23, in one of the Polish museums.

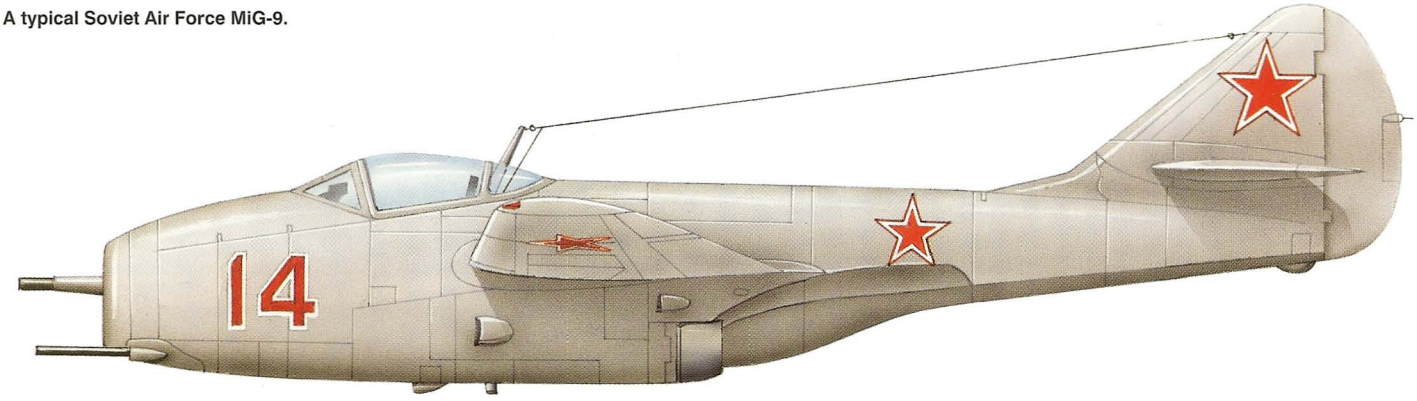
The first prototype I-300 (aircraft F-1)



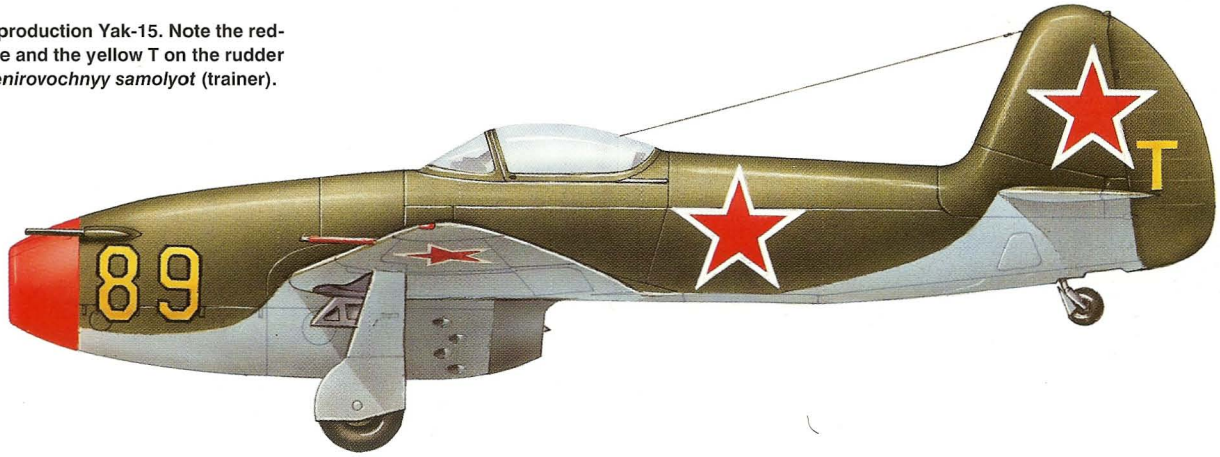
This production MiG-9 (*izdeliye* FS) underwent State acceptance trials at GK NII VVS



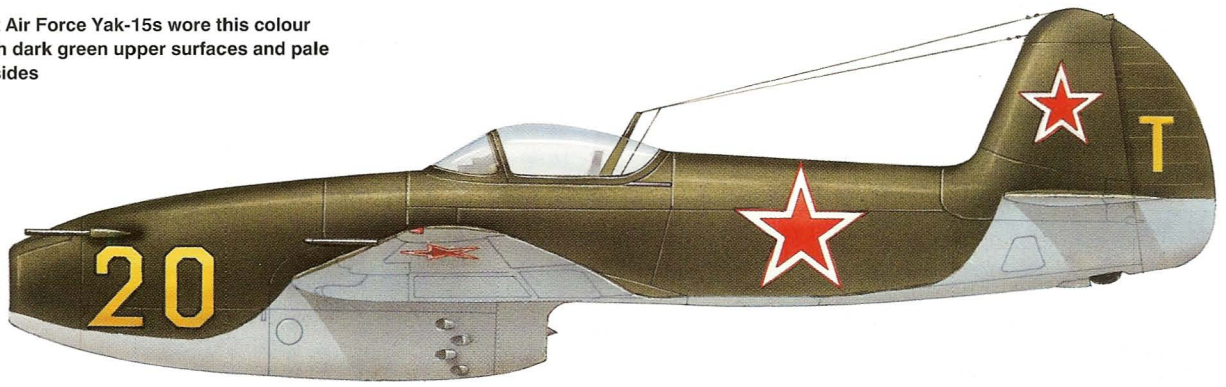
A typical Soviet Air Force MiG-9.



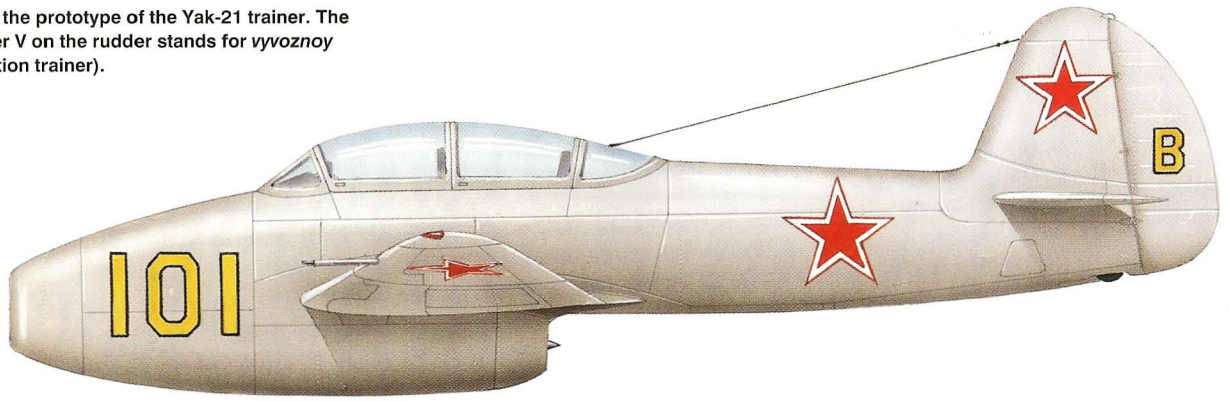
A standard production Yak-15. Note the red-painted nose and the yellow T on the rudder denoting *trenirovochnyy samolyot* (trainer).



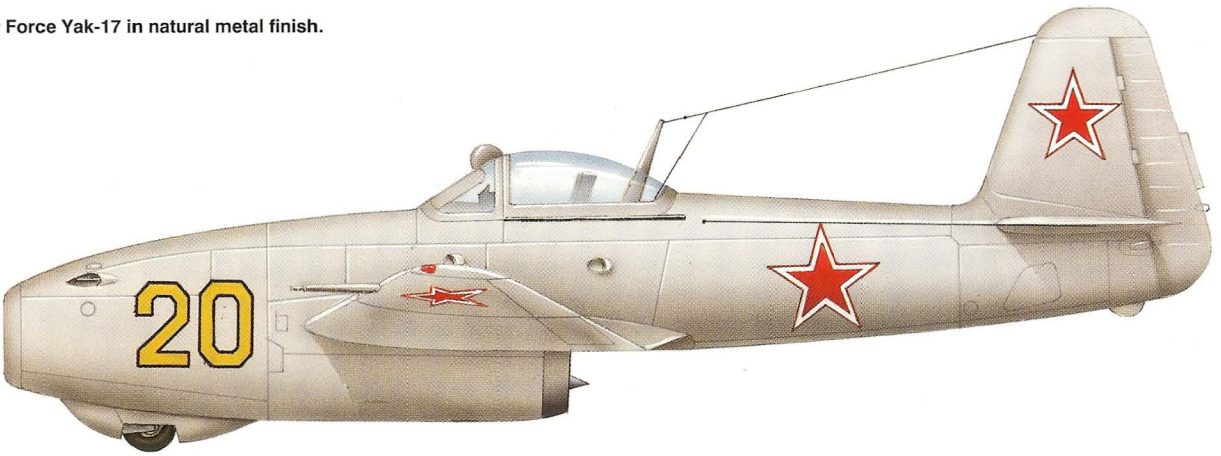
Most Soviet Air Force Yak-15s wore this colour scheme with dark green upper surfaces and pale blue undersides



101 Yellow, the prototype of the Yak-21 trainer. The Cyrillic letter V on the rudder stands for *vyvoznoy* (familiarisation trainer).

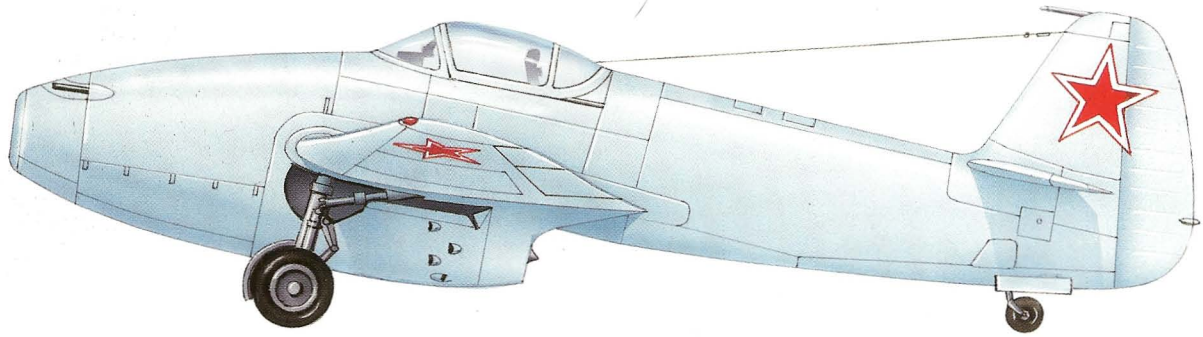


A Soviet Air Force Yak-17 in natural metal finish.

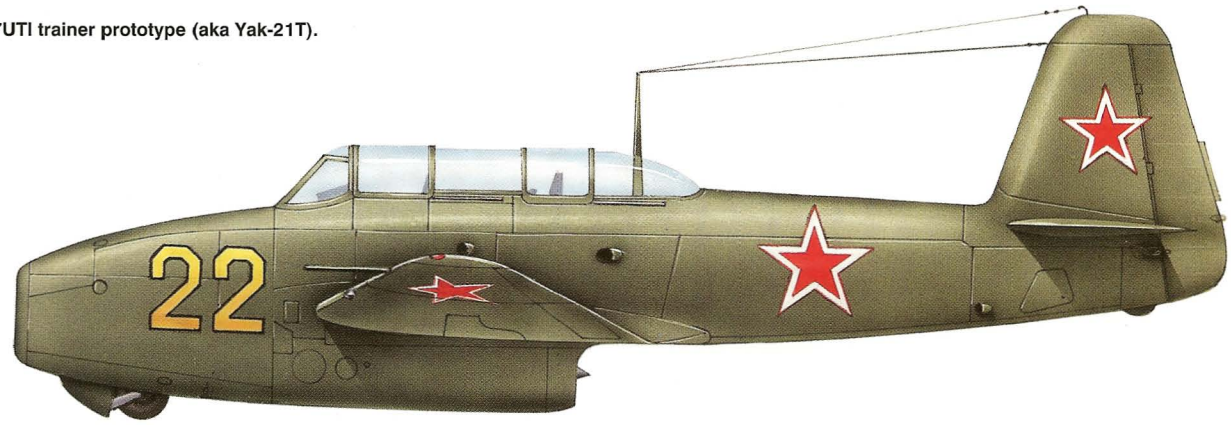


This Yak-17 is preserved at the Central Russian Air Force Museum in Monino.

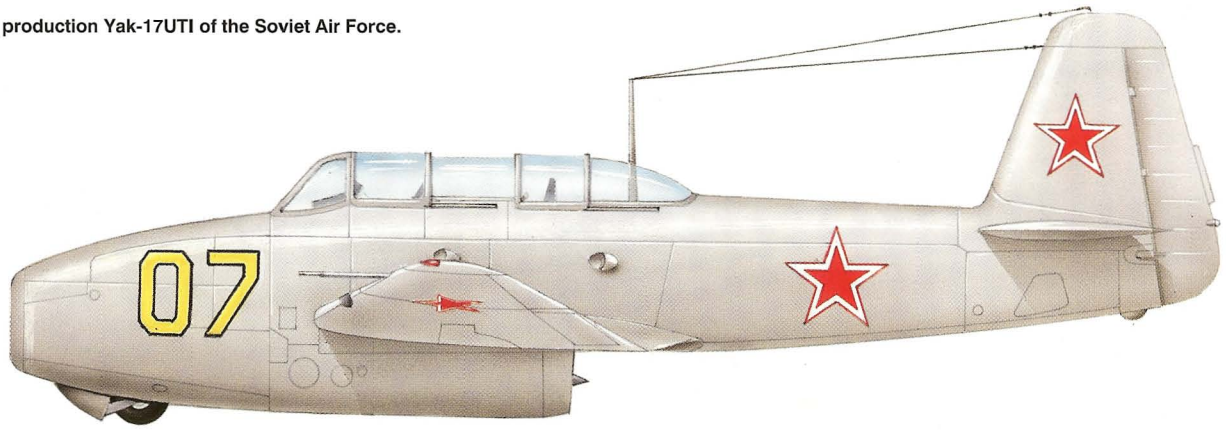
The experimental Yak17-RD10.



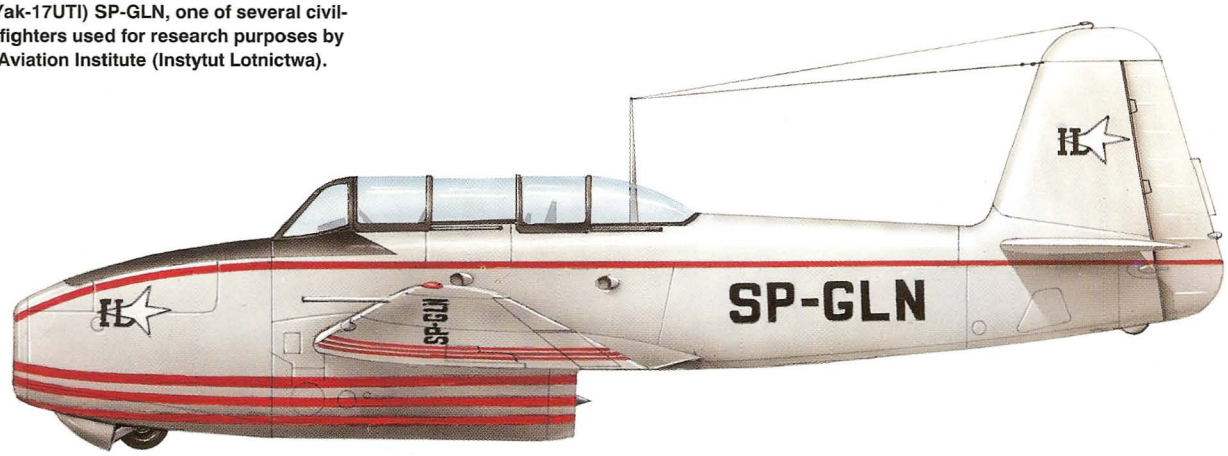
The Yak-17UTI trainer prototype (aka Yak-21T).



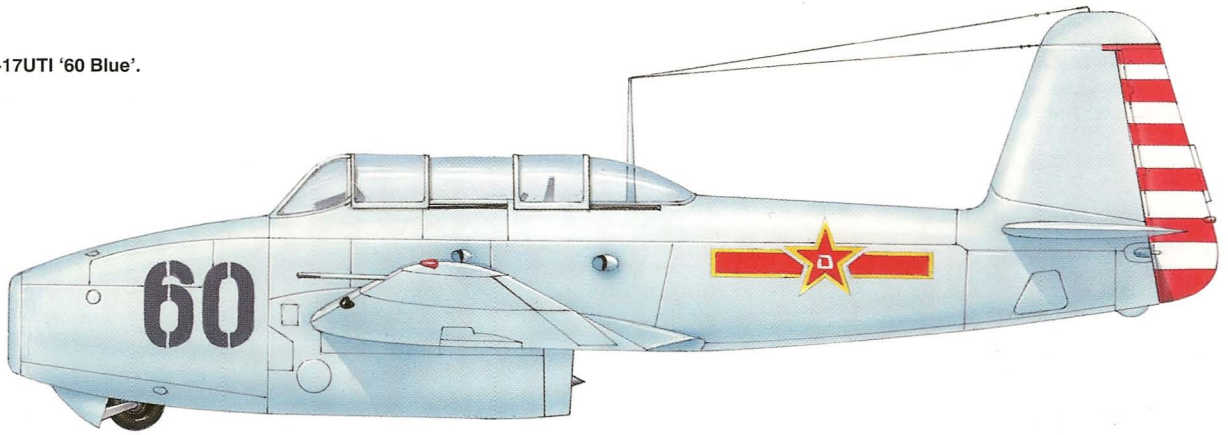
A standard production Yak-17UTI of the Soviet Air Force.



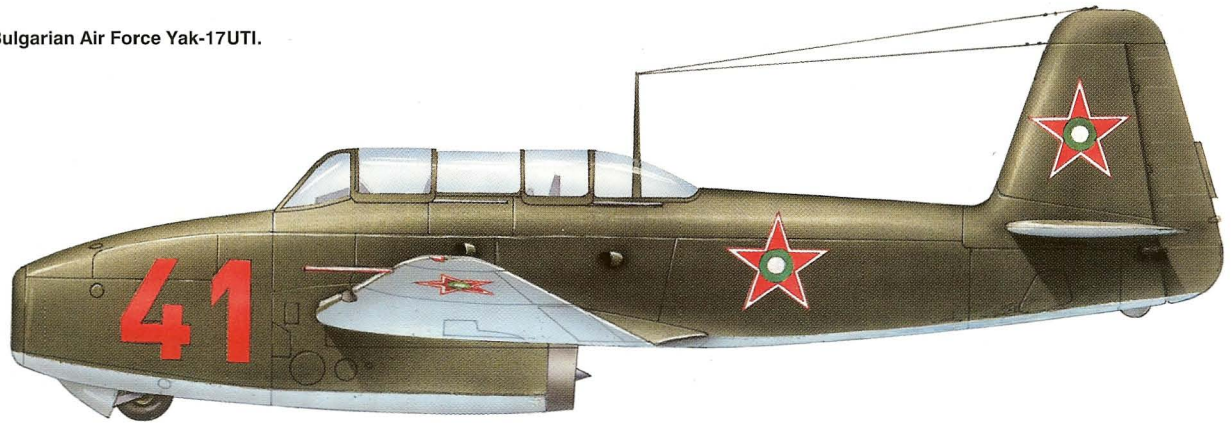
Jak-17W (Yak-17UTI) SP-GLN, one of several civil-registered fighters used for research purposes by the Polish Aviation Institute (Instytut Lotnictwa).



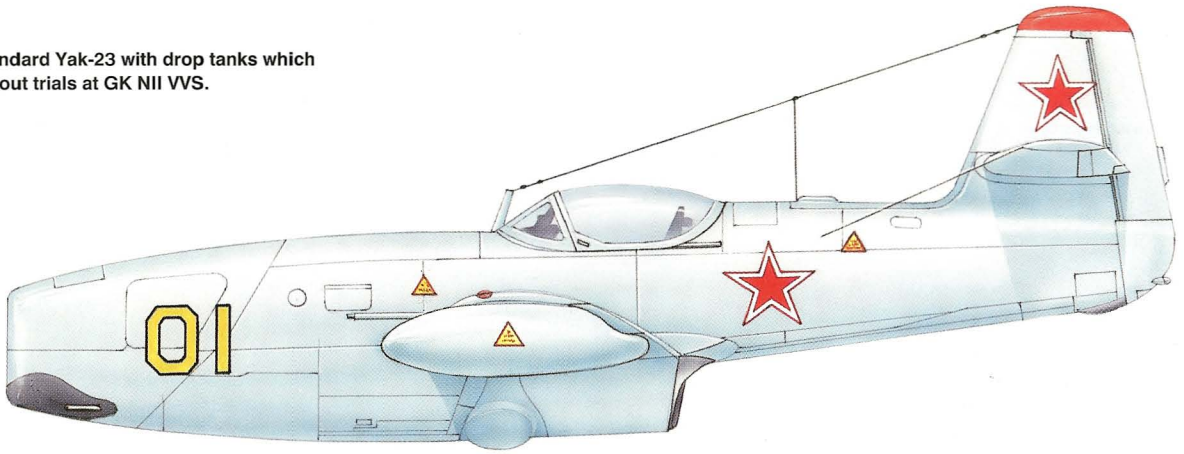
PLAAF Yak-17UTI '60 Blue'.



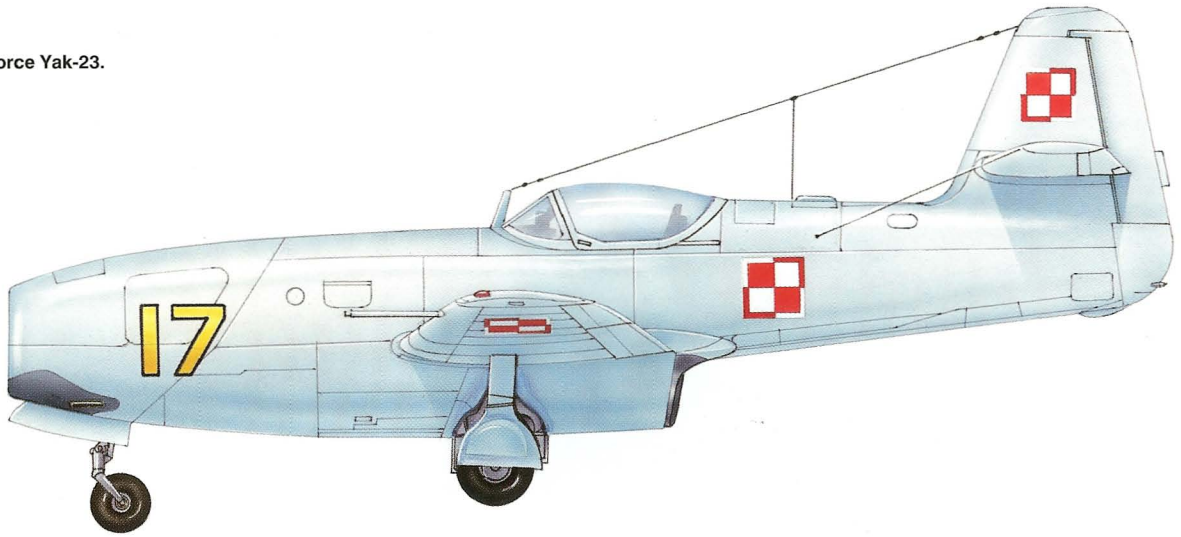
41 Red, a Bulgarian Air Force Yak-17UTI.



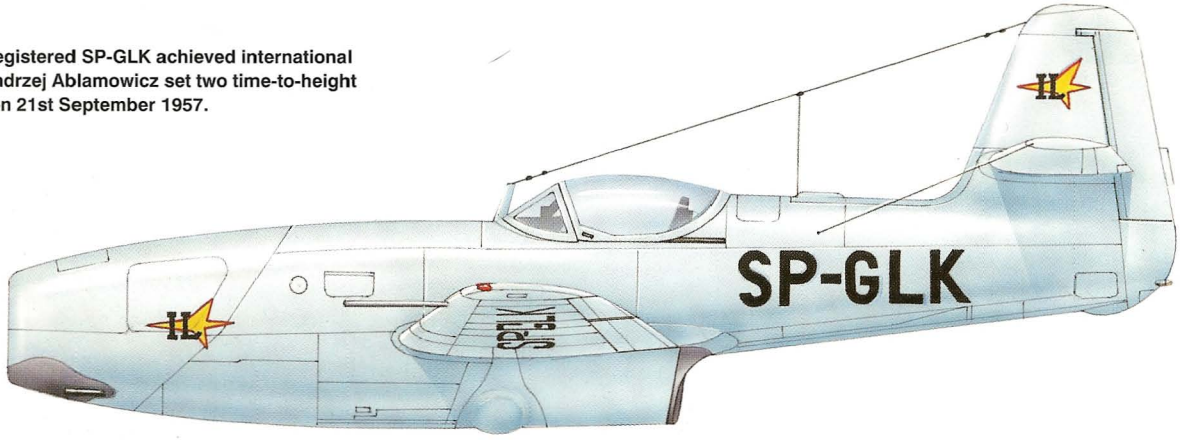
01 Yellow, standard Yak-23 with drop tanks which passed checkout trials at GK NII VVS.



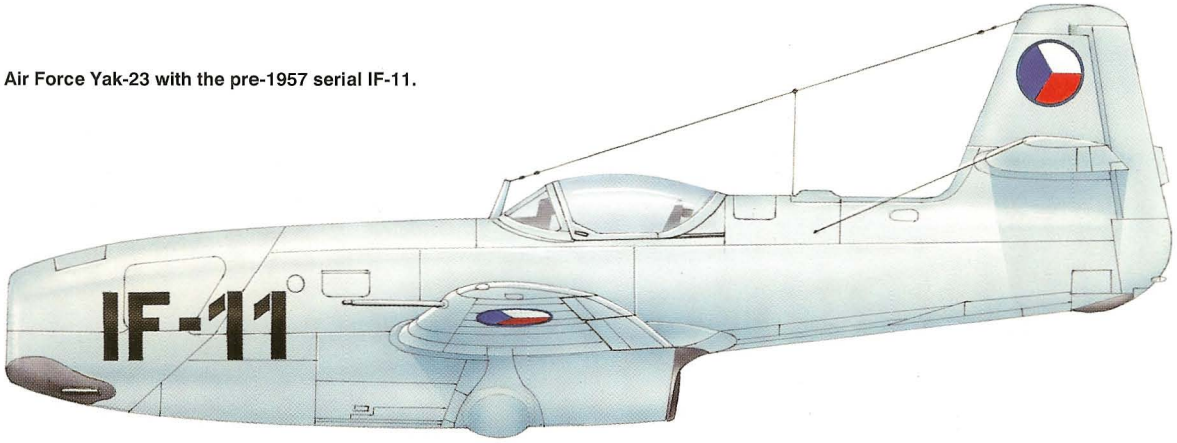
A Polish Air Force Yak-23.



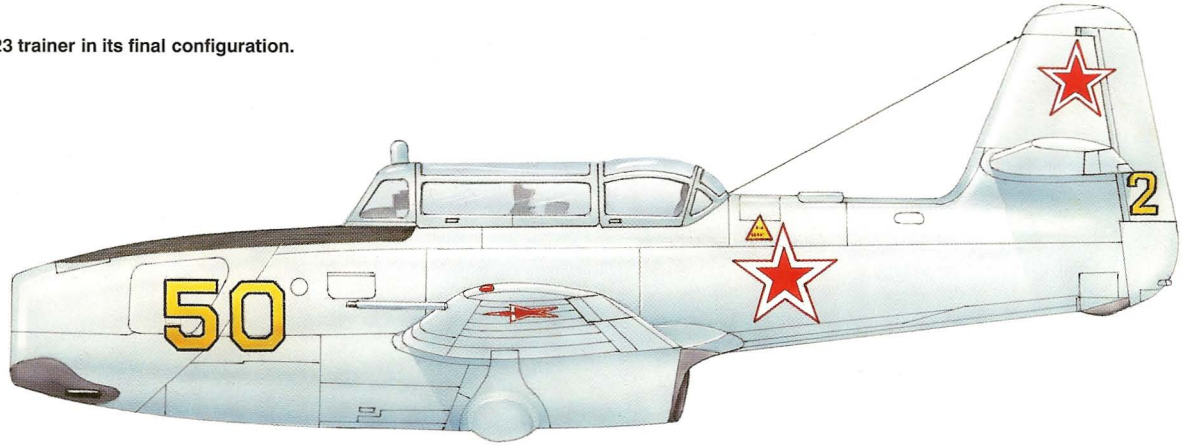
This Yak-23 registered SP-GLK achieved international fame when Andrzej Ablamowicz set two time-to-height records in it on 21st September 1957.



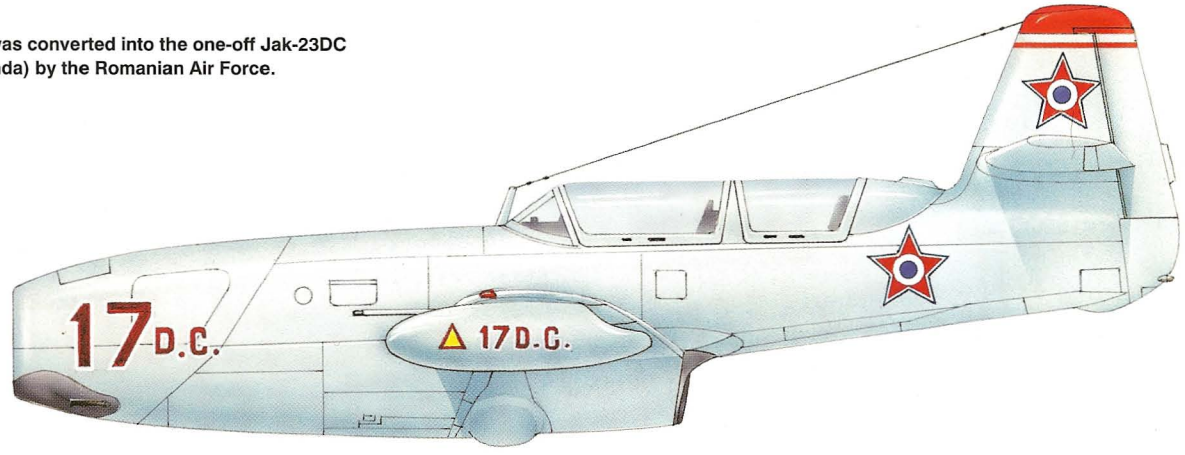
Czechoslovak Air Force Yak-23 with the pre-1957 serial IF-11.



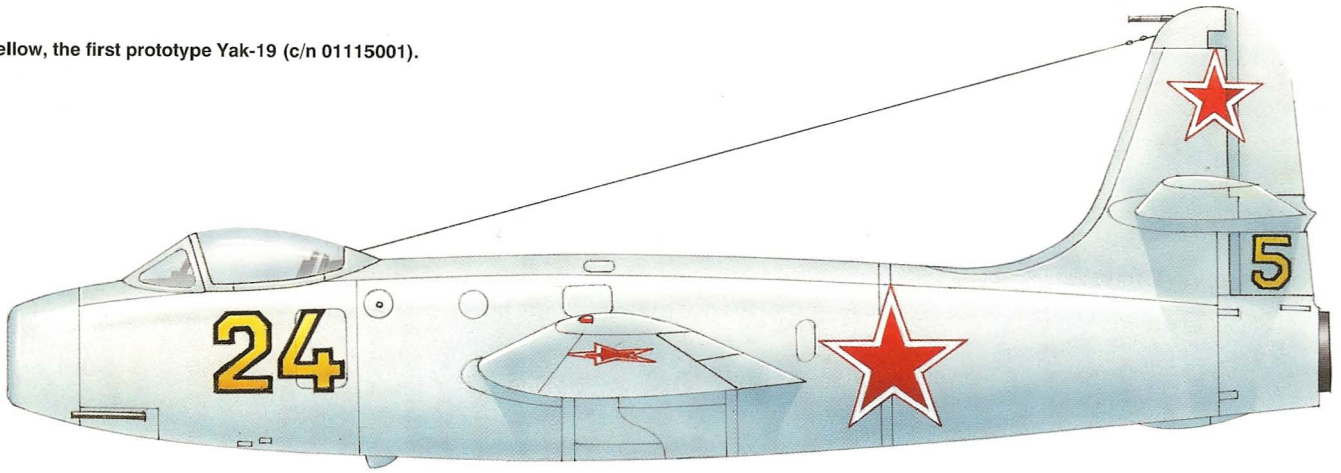
The UTI Yak-23 trainer in its final configuration.



This Yak-23 was converted into the one-off Jak-23DC (dubla comanda) by the Romanian Air Force.

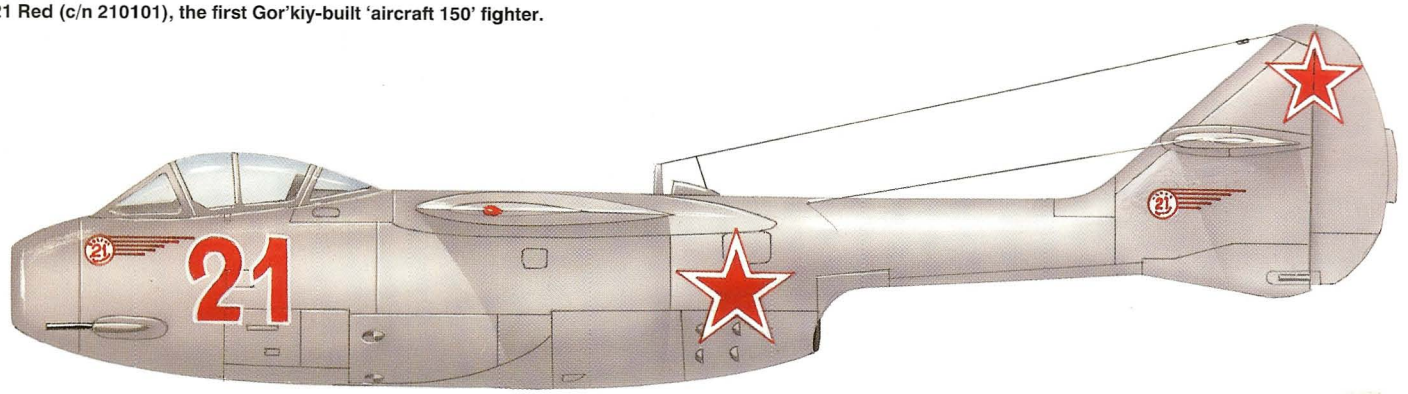


24 Yellow, the first prototype Yak-19 (c/n 01115001).



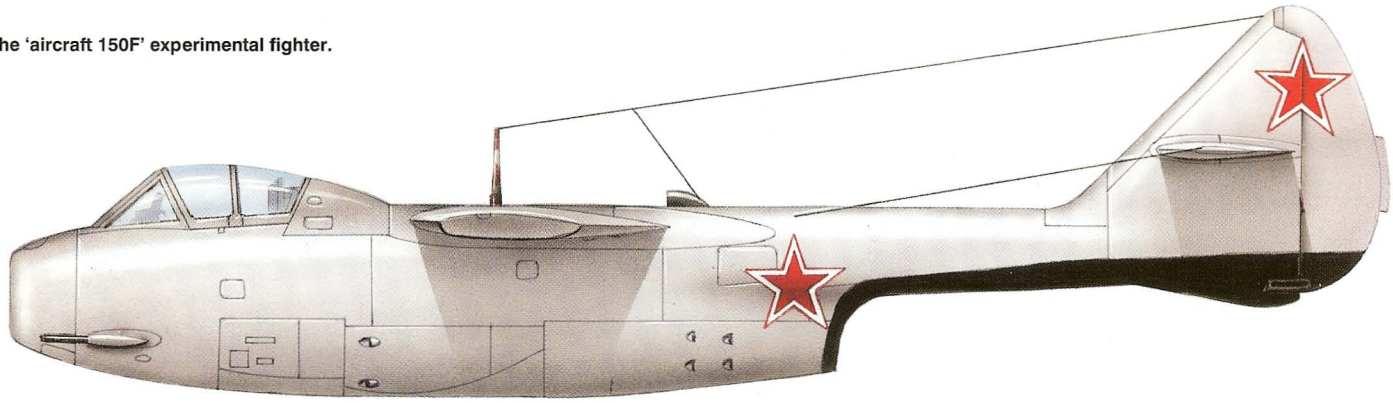
An 'aircraft 150' manufactured by the Moscow aircraft factory No. 381.

21 Red (c/n 210101), the first Gor'kiy-built 'aircraft 150' fighter.

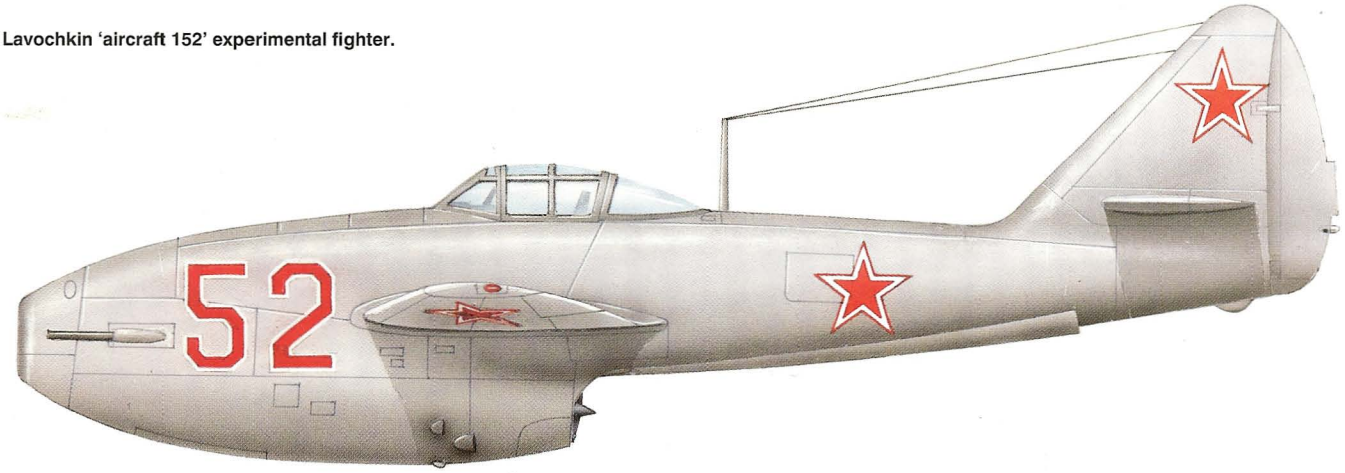


Another Gor'kiy-built '150' which passed manufacturer's flight tests in the winter of 1946-47.

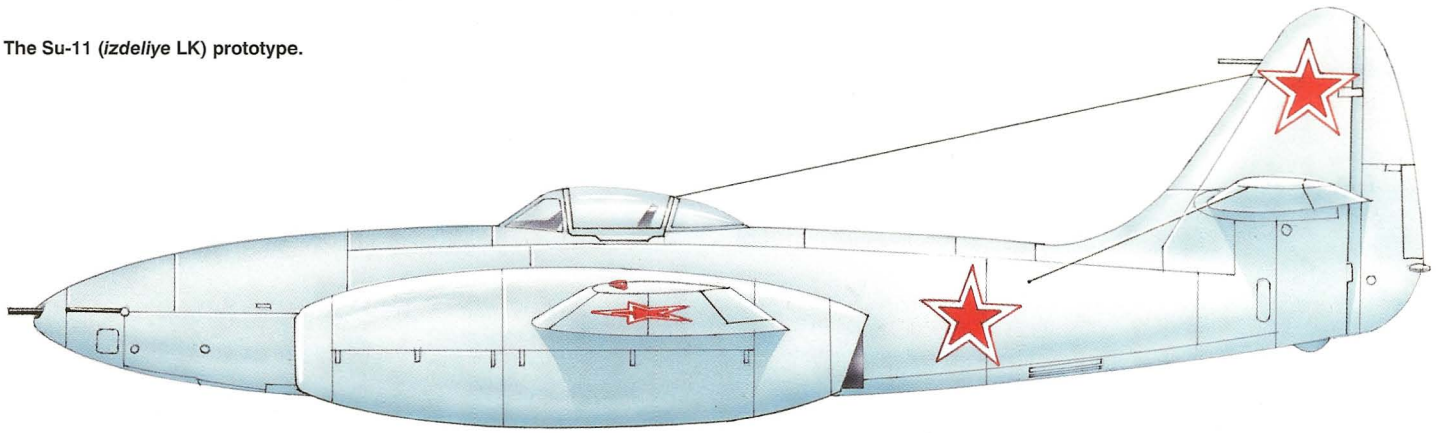
The 'aircraft 150F' experimental fighter.



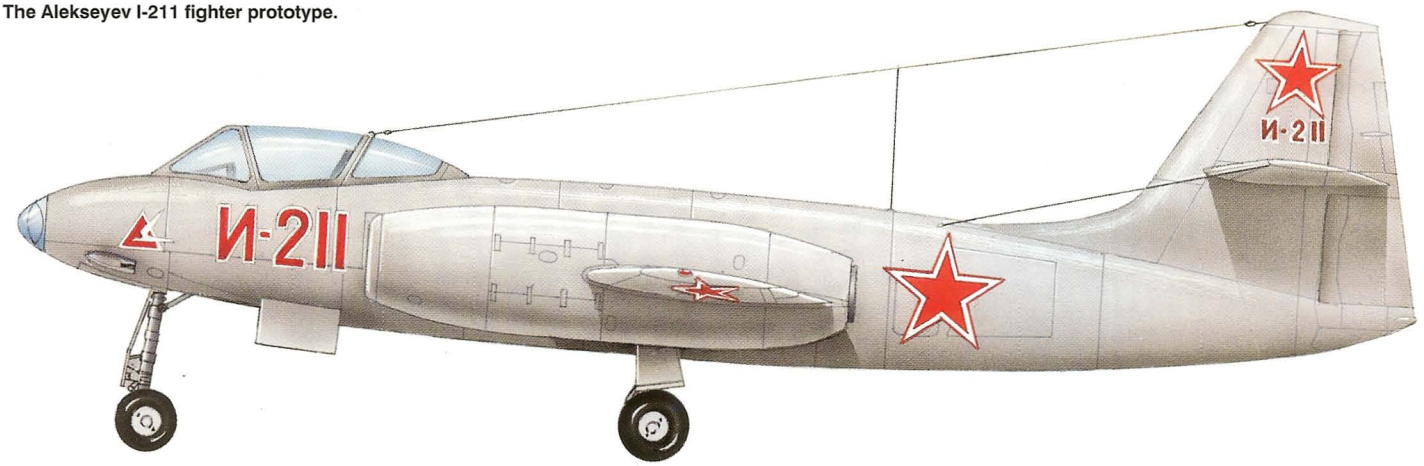
The Lavochkin 'aircraft 152' experimental fighter.

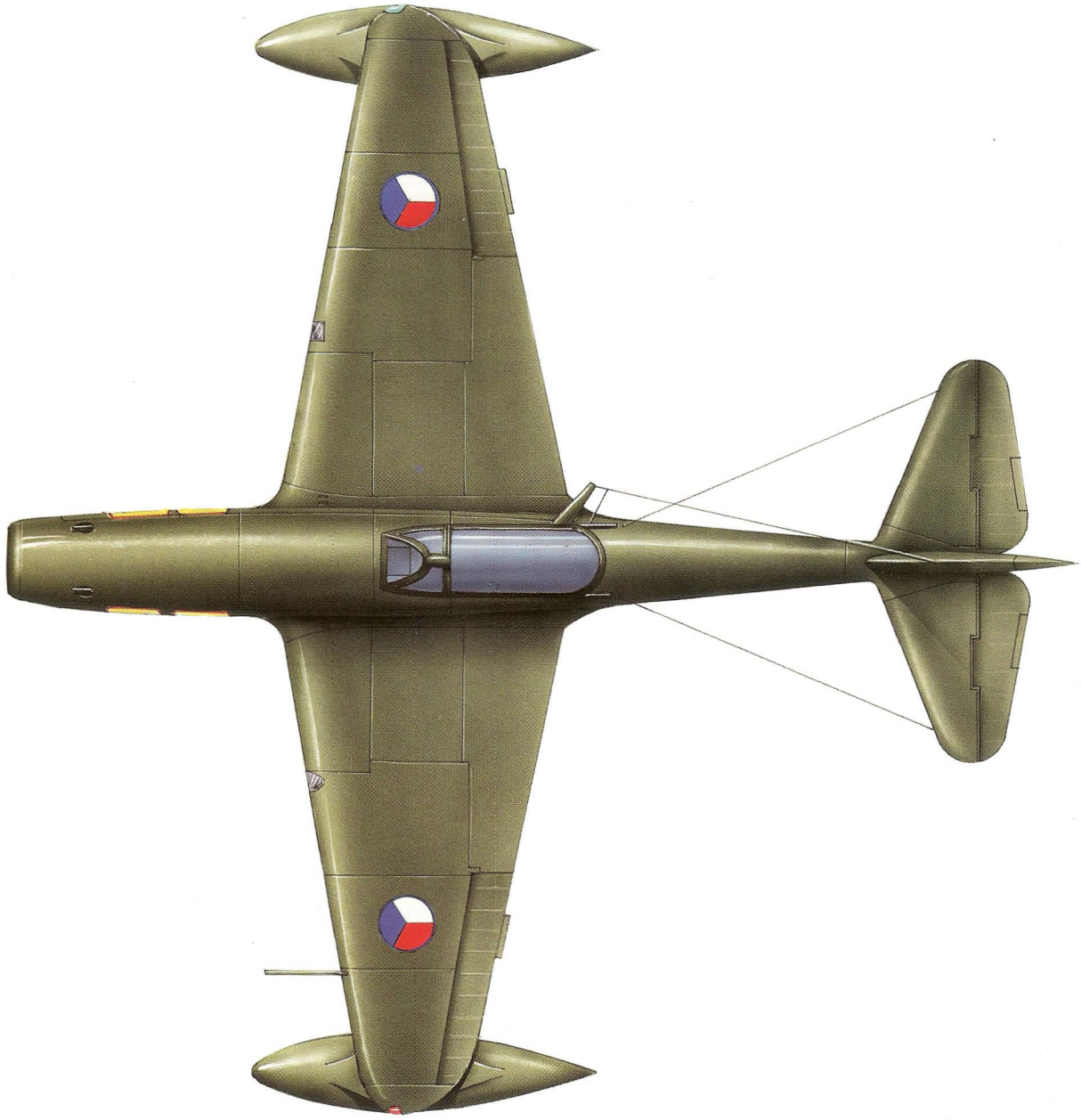


The Su-11 (*izdeliye* LK) prototype.

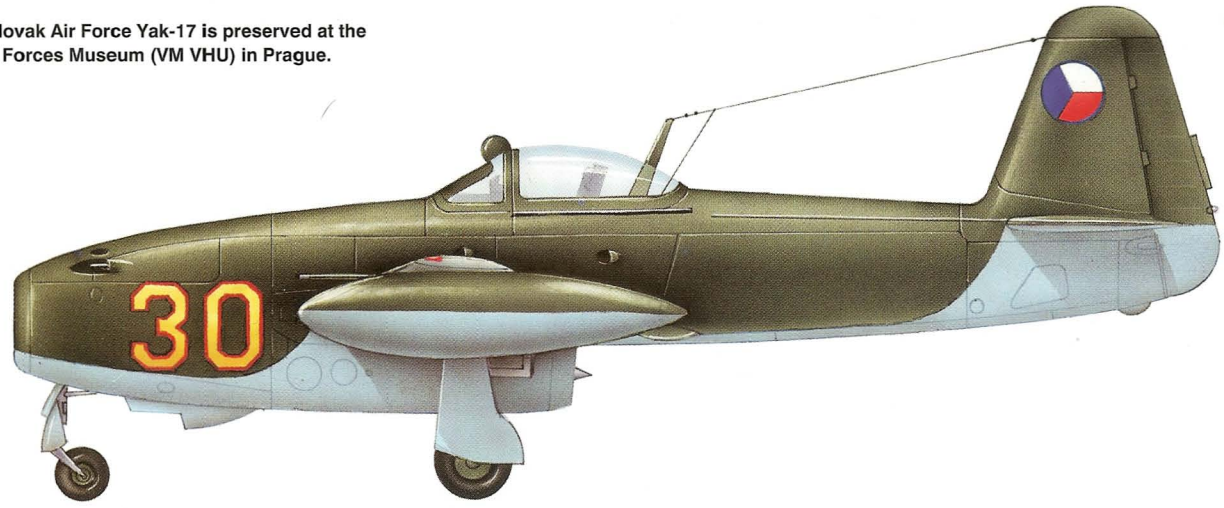


The Alekseyev I-211 fighter prototype.





This Czechoslovak Air Force Yak-17 is preserved at the Czech Armed Forces Museum (VM VHU) in Prague.



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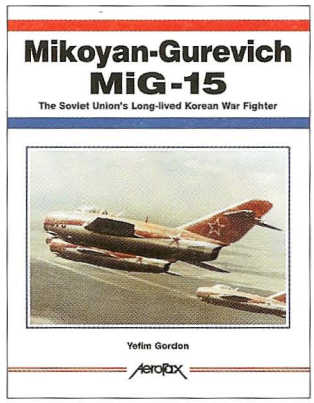

In this Aerofax, compiled from a wealth of first-hand Russian sources, there is a comprehensive history of every evolution of the Soviet Union's swept-wing fighter and its service. Notably in this volume, there are tables listing intricate details of many individual aircraft, a concept which would have been unthinkable in any publications only a few years ago.

There is extensive and detailed photo coverage, again from Russian sources, almost all of which is previously unseen.

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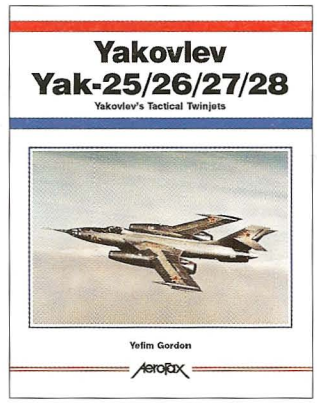

During the 1950s and 1960s the Soviet design bureau Yakovlev was responsible for a series of swept-wing twin-engined jet combat aircraft, known in the west under various names including *Firebar, Flashlight, Mandrake, Mangrove, Brewer* and *Maestro.* All the various models are covered in this Aerofax – as usual with a mass of new information, detail and illustrations from original Russian sources.

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MIKOYAN-GUREVICH MiG-17
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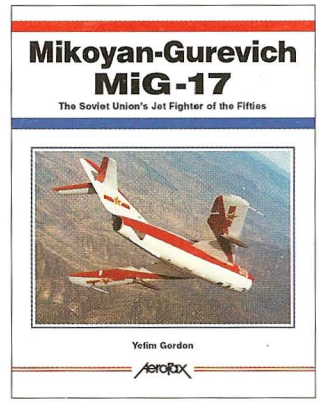

The Soviet Union produced and used around 9,000 MiG-17s. First flown in January 1950, it is an extensively upgraded MiG-15 with a redesigned 'scimitar' wing and lengthened fuselage.

It was built under various designations including the Polish Lim-5P and Lim-6bis and the Czech S-105, and served not only with the Soviet armed forces but with other Warsaw Pact nations, seeing combat in the Middle East, in North Vietnam and in Nigeria.

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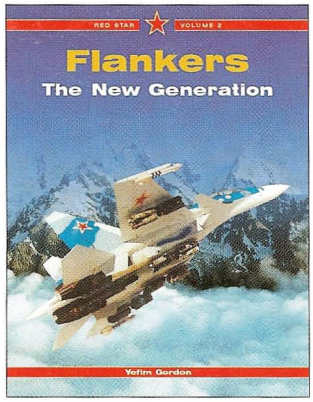

The multi-role Su-30 and Su-35 and thrust-vectoring Su-37 are described in detail, along with the 'big head' Su-23FN/Su-34 tactical bomber, the Su-27K (Su-33) shipborne fighter and its two-seat combat trainer derivative, the Su-27KUB. The book also describes the customised versions developed for foreign customers – the Su-30KI (Su-27KI), the Su-30MKI for India, the Su-30MKK for China and the latest Su-35UB.

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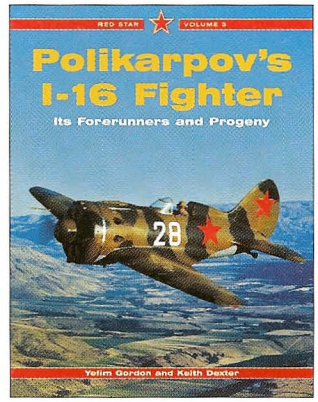

Often dismissed because it did not fare well against its more modern adversaries in the Second World War, Nikolay Polikarpov's I-16 was nevertheless an outstanding fighter – among other things, because it was the world's first monoplane fighter with a retractable undercarriage. Its capabilities were demonstrated effectively during the Spanish Civil War. Covers every variant, from development, unbuilt projects and the later designs that evolved from it.

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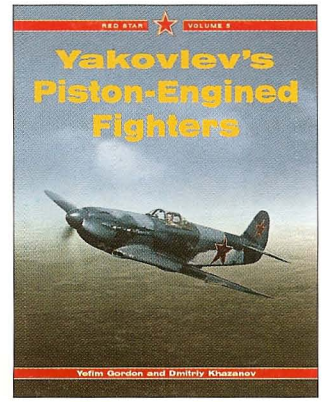

This authoritative monograph describes this entire family from the simple but rugged and agile Yak-1 through the Yak-7 (born as a trainer but eventually developed into a fighter) and the prolific and versatile Yak-9 to the most capable of the line, the Yak-3 with which even the aces of the Luftwaffe were reluctant to tangle. Yak piston fighters also served outside Russia and several examples can be seen in flying condition in the west.

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